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Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System / Mode Select (ATCRBS / Mode S) Airborne Equipment

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FOREWORD

This document is issued as RTCA DO-181E and was prepared by RTCA Special Committee 209 (SC-209). It was approved by the RTCA Program Management Committee on March 17, 2011, and supersedes RTCA/DO-181D, *Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/MODE S) Airborne Equipment*, issued October 2, 2008.

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 helps 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.

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1 PURPOSE AND SCOPE

1.1 Introduction

This document sets forth minimum operational performance standards for Mode Select (Mode S)[1] 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.

Compliance with these standards is recommended as a means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine operations.

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 Mode S airborne equipment will necessarily include all of the foregoing components as separate units; this will depend on the design configuration chosen by the manufacturer. Additional functions and components that may refer to expanded equipment capabilities are identified as additional capabilities. Equipment features that are beyond the scope of this document may be developed in future RTCA activities.

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. If the equipment implementation includes design considerations for use in conjunction with TCAS functionality, the guidelines contained in the most current issue of RTCA/DO-185, *Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment*, should be considered.

1.2 System Overview

1.2.1 The Function of Mode S

Mode S is a cooperative surveillance and communication system for air traffic control. It employs ground-based and airborne sensors (interrogators) and airborne transponders. Ground-air-ground data link communications can be accommodated integrally with the surveillance interrogations and replies. Mode S has been designed as an evolutionary addition to the Air Traffic Control Radar Beacon System (ATCRBS) to provide the enhanced surveillance and communication capability required for air traffic control automation. To facilitate the introduction of Mode S into the ATCRBS system, both ground and airborne Mode S installations include full ATCRBS capability. Mode S

[1] For the purpose of this document, the term "Mode S" implies a combined ATCRBS/Mode S capability.

interrogators provide surveillance of ATCRBS-equipped aircraft, and Mode S transponders will reply to ATCRBS interrogators. In addition, the data link potential of Mode S permits use of the transponder for a number of air traffic control (ATC) and aircraft separation assurance (ASA) functions.

The monopulse techniques used in Mode S surveillance allow improved position determination of ATCRBS targets while reducing the number of required interrogations. This reduction of ATCRBS interrogations and replies improves the radio frequency (RF) interference environment.

A principal feature of Mode S that differs from ATCRBS is that each aircraft is assigned a unique address code. Using this unique code, interrogations can be directed to a particular aircraft and replies unambiguously identified. Channel interference is minimized because a sensor can limit its interrogations to targets of interest. In addition, by proper timing of interrogations, replies from closely-spaced aircraft can be received without mutual interference. The unique address in each interrogation and reply also permits the inclusion of data link messages to or from a particular aircraft.

1.2.2 Major Operating Characteristics

In order to facilitate a smooth transition from the existing ATCRBS system, Mode S uses the same frequencies for interrogations and replies as ATCRBS (1030 and 1090 MHz, respectively). The Mode S waveforms (modulation techniques) have been chosen to reduce the interference between ATCRBS and Mode S. The Mode S interrogation is transmitted using binary differential phase shift keying (DPSK). With proper demodulation, the information content is detectable in the presence of overlaid ATCRBS signals. The modulation of the downlink transmission from the transponder is pulse position modulation (PPM) which is inherently resistant to ATCRBS random pulses. The information content of both uplink and downlink transmissions is further protected by parity check bits generated by a cyclic coding algorithm.

Each Mode S interrogation contains a 24-bit discrete address which allows a very large number of aircraft to operate in the air traffic control environment without occurrence of a redundant address. The overlaying of the parity check bits on the discrete address assures that a message will be accepted only by the aircraft addressed and that the probability of an erroneous message being accepted is extremely small.

Because the interference resistance of the Mode S system relies on the DPSK modulation process on the uplink and the PPM format on the downlink, the DPSK demodulation processor within the transponder must be designed carefully, and precise timing of the downlink pulses is required.

1.2.3 System Performance

1.2.3.1 Surveillance Performance

The Mode S interrogator provides surveillance of all beacon-equipped aircraft (both ATCRBS and Mode S) within its line-of-sight coverage. The nominal maximum range is 200 NM. The Mode S interrogators can provide surveillance of a large number of aircraft with better accuracy than ATCRBS. With the capability to reinterrogate a target within an antenna scan, the overall surveillance reliability of Mode S is greater than 99 percent.

1.2.3.2 Data Link Performance

Mode S can provide for ground-to-air, air-to-ground and air-to-air data link. The critical nature of many of the messages carried by Mode S will require a high degree of message integrity. Error-detecting codes in both interrogations and replies are designed to produce an undetected error rate of better than one in 10^7. By requiring technical acknowledgment of a correct message receipt, along with the sensor's capability to re-interrogate, if necessary, a message delivery reliability of greater than 99 percent in one antenna scan is achieved. The Mode S data link capacity exceeds the maximum data load expected to exist in the foreseeable future.

1.2.4 Basic System Protocol

As an aircraft equipped with a transponder enters the airspace served by a Mode S interrogator, it receives an ATCRBS/Mode S All-Call interrogation which has a waveform that can be understood by both ATCRBS and Mode S transponders. ATCRBS transponders reply with a standard ATCRBS reply format, while Mode S transponders reply with a Mode S format that includes their discrete (24-bit) Mode S address. This address, together with location of the Mode S aircraft, is entered into a file (put on roll-call), and on the next scan the Mode S-equipped aircraft is discretely addressed. Since azimuth and range are known for all aircraft on roll-call, they are interrogated according to a precomputed schedule. Within this schedule are ATCRBS/Mode S All-Calls which permit the tracking of known ATCRBS aircraft and the acquisition of additional ATCRBS and Mode S aircraft entering the served airspace.

The discrete interrogations of a Mode S-equipped aircraft contain a command field that may lock out the Mode S transponder to further ATCRBS/Mode S All-Call interrogations (Mode S lockout). ATCRBS interrogations originating from ATCRBS interrogators are not affected by this lockout; Mode S transponders reply to ATCRBS interrogations under all circumstances. As a Mode S aircraft flies into airspace served by another Mode S interrogator, the first Mode S interrogator may pass position information and the aircraft's discrete address *via* ground lines to the interrogator now providing service. Thus, the need to unlock the Mode S transponder may be eliminated, and the second interrogator immediately schedules discrete roll-call interrogations for the aircraft. In regions where Mode S interrogators are not connected *via* ground lines, a protocol exists that permits the Mode S transponder to be in a lockout state for only those interrogators which have the aircraft on roll-call. Therefore, as the aircraft flies into airspace served by a new Mode S interrogator, the new interrogator may acquire the aircraft *via* its reply to an All-Call interrogation. The Mode S-Only All-Call is used by interrogators if Mode S targets are to be acquired without eliciting replies from ATCRBS targets that may be present.

The destination address of this interrogation consists of all ONEs. All Mode S transponders will reply to this interrogation giving their discrete address. In turn, an ATCRBS-Only All-Call is used by the interrogator if ATCRBS targets are to be acquired without eliciting replies from Mode S targets.

Aircraft are tracked by the interrogator throughout its assigned airspace. A Mode S aircraft reports in its replies either its altitude or its ATCRBS 4096 code depending on the type of discrete interrogation received. During each scan, interrogations of ATCRBS aircraft are made in both Mode A and Mode C.

If, on scanning through a Mode S-equipped aircraft's location, the interrogator does not receive a valid reply, it can re-interrogate a limited number of times. Interrogators normally interrogate at low power and re-interrogate at high power when the low power attempt fails.

Several ATCRBS/Mode S All-Call interrogations are transmitted during the time each ATCRBS target is in the beam. Thus both ATCRBS and Mode S aircraft are served when flying through the system with a minimum of RF channel loading.

1.2.5 Mode S Message Content

1.2.5.1 Address/Parity

All discrete Mode S interrogations (56-bit or 112-bit) and replies (except the All-Call reply) contain the 24-bit discrete address of the Mode S transponder upon which 24 error-detecting parity check bits are overlaid. In the All-Call reply, the 24 parity check bits are overlaid on the Mode S interrogator's address, and the transponder's discrete address is included in the clear in the text of the reply.

1.2.5.2 Surveillance

The primary function of Mode S is surveillance. For the Mode S transponder, this function can be accomplished by use of "short" (56-bit) transmissions in both directions. In these transmissions, the aircraft reports its altitude or ATCRBS 4096 code as well as its flight status (airborne, on the ground, alert, Special Position Identification [SPI], etc.).

There are two types of squitter transmissions, i.e., transmissions spontaneously generated by the transponder. The short (56-bit) squitter has the format of an All-Call reply (DF=11) and is transmitted by a transponder approximately once every second. This squitter is received and used by aircraft equipped with TCAS to detect the presence and 24-bit address of Mode S equipped aircraft within signal range. The extended (112-bit) squitter (DF=17) contains the same fields as the short squitter, plus a 56-bit message field that is used to broadcast Automatic Dependent Surveillance (ADS) data approximately four times per second. The Extended Squitter is used by TCAS or other air-air applications, and ground ATC users for passive air and surface surveillance.

"Special surveillance" interrogations from airborne collision avoidance systems are addressed to Mode S-equipped aircraft based upon the address extracted from squitter signals. These interrogations are used for Mode S target tracking and collision threat assessment.

1.2.5.3 Data Link Communications

The discrete addressing and digital encoding of Mode S transmissions permit their use as a digital data link. The interrogation and reply formats of the Mode S system contain sufficient coding space to permit the transmission of data. Such data transmissions may be used for air traffic control purposes, air-to-air data interchange for collision avoidance, or may be used to provide flight advisory services such as weather reports, Automated Terminal Information System (ATIS), etc.

Most Mode S data link transmissions will be handled as one 56-bit message included as part of "long" (112-bit) interrogations or replies. These transmissions include the message in addition to surveillance data and thus will generally be used in place of, rather than in addition to, a surveillance interrogation and/or reply.

An efficient transmission of longer messages is accomplished by the extended length message (ELM) capability. Using this capability, a sequence of up to 16 80-bit message segments (each within a 112-bit transmission) can be transmitted, either ground-to-air or air-to-ground and can be acknowledged with a single reply/interrogation. ELMs do not contain surveillance data and thus cannot substitute for a surveillance interrogation-reply cycle.

1.3 Operational Goals

Mode S is a combined secondary surveillance radar and a potential ground-air-ground data link system capable of providing aircraft surveillance and communications necessary to support automated ATC in the dense traffic environments expected in the future. It is capable of common-channel interoperation with the ATC beacon system and thus may be implemented over an extended ATCRBS to Mode S transition period. In supporting ATC automation, Mode S is capable of providing the reliable communications necessary for data link services.

1.4 Operational Applications

1.4.1 The ATCRBS Environment

A great majority of the combined civil and military aircraft fleets are equipped with ATCRBS transponders. In terms of exposure to the ATC system, this implementation is estimated to be greater than 90 percent of the hours flown.

Because of operating requirements, approximately one half of transponder-equipped civil aircraft have altitude reporting (Mode C) capability.

Requirements for operation in high altitude airspace and in specific high density terminal control areas have caused an increase in the number of aircraft equipped with Mode C.

1.4.2 The Mode S Environment

Mode S offers more options for the aircraft operator than ATCRBS. Different levels of service may be available to satisfy varying user requirements.

1.4.3 Mode S Transponder Levels

Mode S transponders provide for both ground-to-air and air-to-air surveillance.

The data link function of Mode S transponders provides for information transfer in both directions between ground and air and between airborne units. Data link implementation varies and depends on the amount of information to be exchanged.

Possible implementation configurations and additional transponder features are summarized in the following paragraphs.

1.4.3.1 Level 1 Transponders

The Level 1 Transponder supports the surveillance functions of both ATCRBS and Mode S ground sensors and the surveillance functions of airborne interrogators. This transponder can also reply to an airborne interrogator thereby making its presence known; to do this, it need only handle short interrogations and replies.

Level 1 Transponders **shall** have the capabilities prescribed for:

a. Mode A identity and Mode C pressure-altitude reporting,
b. ATCRBS/Mode-S all-call and Mode S-only all-call transactions,
c. Addressed surveillance altitude and identity transaction,
d. Lockout protocols,
e. Basic data protocols except data link capability reporting, and
f. Air-to-air service and squitter transactions.

Note: *Level 1 permits SSR surveillance based on pressure-altitude reporting and the Mode A identity code. In an SSR Mode S environment, technical performance relative to a Mode A/C transponder is improved because of Mode S selective aircraft interrogation.*

1.4.3.2 Level 2 Transponders

Level 2 Transponders **shall** have the capabilities of §1.4.3.1 and additionally support the receipt of long interrogations and the generation of long replies. The Level 2 Transponder supports all of the surveillance functions and also supports:

a. Bi-directional air-to-air information exchange
b. Ground-to-air data uplink, Comm-A
c. Air-to-ground data downlink, Comm-B
d. Multisite message protocol
e. Data link capability reporting
f. Aircraft identification reporting
g. TCAS/ACAS crosslink capability
h. Overlay Command Capability (see §2.2.19.1.12.1, §2.2.19.1.12.2 & §2.2.19.1.12.6.2)

The ground-air-ground data link capability comprises a multitude of services and can be implemented according to the number and kind of services available, depending on the mission requirements of the aircraft. Protocols provide a means of reporting to the ground the specifics of each individual installation.

Specific capabilities of a Level 2 or higher transponder have been defined for operation in European airspace. Requirements for Elementary Surveillance (ELS) and Enhanced Surveillance (EHS) compliant transponders are included in this document (§2.2.24 and §2.2.25). Specific data registers and content appropriate for these capabilities are provided.

1.4.3.3 Level 3 Transponders (Uplink ELM Capability)

In addition to the capabilities of the Level 1 and Level 2 Transponders, the Level 3 transponder is able to receive ELMs from the ground. ELMs are received in the Comm-

C format and consist of a burst of uplink transmissions that need not be replied to individually but are acknowledged in a reply containing a summary of the received interrogations.

Level 3 Transponders **shall** have the capabilities of §1.4.3.2 and also those prescribed for ground-to-air Extended Length Message (ELM) communications.

Note: *Level 3 permits extended length data link communications from ground-to-air and thus may provide retrieval from ground-based data banks and receipt of other air traffic services which are not available with Level 2 transponders.*

1.4.3.4 Level 4 Transponders (Full ELM Capability)

In addition to all the capabilities of a Level 3 Transponder, the Level 4 Transponder can generate ELMs for transmittal to the ground by using the Comm-D format.

Level 4 transponders **shall** have the capabilities of §1.4.3.3 and also those prescribed for air-to-ground extended length message (ELM) communications.

Note: *Level 4 permits extended length data link communications from air to ground and thus may provide access from the ground to airborne data sources and the transmission of other data required by air traffic services which are not available with Level 2 transponders.*

1.4.3.5 Level 5 Transponders (Enhanced Data Link Protocol Capability)

In addition to the full ELM capability, the Level 5 Transponder can support the enhanced data link protocols. The protocols provide for increased data link capacity by permitting data link transactions with more than one Mode S interrogator at a time without the need for multisite coordination. These protocols are fully conformant to the data link transponder protocols description of §2.2.19.1 to §2.2.20.2.1 (the standard protocols) and are therefore compatible with interrogators that are not equipped for the enhanced protocol.

Level 5 transponders **shall** have the capabilities of §1.4.3.4 and also those prescribed for enhanced Comm-B and extended length message (ELM) communications.

Note: *Level 5 permits Comm-B and extended length data link communications with multiple interrogators without requiring the use of multisite reservations. The Level 5 Transponder has a higher minimum data link capacity than the other transponder levels.*

1.4.4 Optional Additional Features

Some transponder installations may support additional features:

- **TCAS Compatibility** – TCAS compatible transponders will have the capabilities described in §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5, (see §2.2.22).

- **Antenna Diversity** – in aircraft with gross mass in excess of 5700 kg or a maximum cruising true airspeed capability in excess of 324 km/h (175 kt), or co-installation with airborne collision avoidance systems may require the transponder to operate in the diversity mode, i.e., the use of two antennas, receivers and transmitting channels.

- **Extended Squitter** – Extended squitter transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 also in addition to those prescribed for extended squitter operation (see §2.2.23). The requirements for Extended Squitter message formats and information content are contained in the *Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)* (RTCA DO-260B / EUROCAE ED-102A or latest version).

- **Dataflash Application –** transponders implementing Dataflash mode will adhere to the requirements contained in Appendix C.

- **Hijack Mode Capability** – Transponders implementing the Hijack mode will adhere to the requirements contained in Appendix D.

- **Elementary Surveillance** – elementary surveillance transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 in addition to those requirements prescribed for elementary surveillance operation (see §2.2.24).

- **Enhanced Surveillance** – enhanced surveillance transponders will have the capabilities of §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 in addition to those requirements prescribed for enhanced surveillance operation (see §2.2.25).

- **Surveillance Identifier Code (SI)** – transponders with the ability to process SI codes have the capabilities of §1.4.3.1, §1.4.3.2, §1.4.3.3, §1.4.3.4 or §1.4.3.5 (see §2.2.14.4.37).

These additional features and corresponding identification codes are summarized in Table 1-1.

Table 1-1: Transponder Optional Additional Features

Additional Features	ID Code
TCAS Compatibility	a
Antenna Diversity	d
Extended Squitter	e
Dataflash	f
Hijack Mode Capability	h
Elementary Surveillance (only)	l
Enhanced Surveillance (including Elementary Surveillance)	n
Surveillance Identifier Code (SI)	s

Note: *SI capability is included by meeting the requirements in these MOPS.*

1.4.5 Minimum Output Power Level Designation

Two minimum peak output power levels are supported by this version of these MOPS, 125 watts (21.0 dBW), which is designated as Class 1 equipment, and 70 watts (18.5 dBW), which is designated as Class 2 equipment. For more information on output power levels, see §2.2.3.2.

Class 1 equipment is intended for use in aircraft that operate at altitudes above 15000 ft, or have a maximum cruising true airspeed in excess of 175 kt (324 km/h).

Class 2 equipment may be used in aircraft that operate at altitudes not exceeding 15000 ft, and have a maximum cruising true airspeed not exceeding 175 kt (324 km/h).

Note: *Level 4 or 5 transponders are not expected to be developed using Class 2 power.*

1.4.6 Transponder Labeling

Each transponder **shall** be clearly labeled with its actual functional level, minimum peak output power, and its optional additional features. The label **shall** contain the word "Level" followed by one digit between 1 and 5. (see §1.4.3.1 through §1.4.3.5), followed by the ID Codes for the incorporated optional additional features as shown in Table 1-1, followed by the transponders' minimum peak output power designation as "Class 1" or "Class 2" (see §1.4.5).

Example 1 – For a Level 2 transponder that incorporates Extended Squitter, Elementary Surveillance and SI capabilities with a minimum peak output power of 70 watts (18.5 dBW): the transponder would be labeled "Level 2els, Class 2."

Example 2 – For a Level 4 transponder that incorporates TCAS compatibility, antenna diversity, Extended Squitter, Enhanced Surveillance and SI capabilities, with a minimum peak output power of 125 watts (21.0 dBW), the transponder would be labeled "Level 4adens, Class 1."

The label should be clearly visible when the transponder is mounted on the aircraft. In the case of a change of transponder level or capability, the label must be changed appropriately.

Note: *For transponders where "Level" or "additional features" might be changed through an approved software update, a means to display the labeling electronically would meet the above intent.*

1.4.7 Use of the Mode S Data Link

The foregoing operational categories include Mode S applications for aircraft separation assurance services. In addition, the data link is available for other uses including:

a. flight advisory information delivered to the pilot.
b. visual confirmation of ATC instructions.
c. pilot participation in ATC through use of an advanced display.
d. future automation of ATC.

1.4.8 Airborne Equipment

The transponder is the principal avionics component of Mode S. It performs all the necessary surveillance functions by providing the appropriate reply to ATCRBS and Mode S interrogations addressed to the aircraft.

When used for data link transmissions, the transponder accepts the message as it arrives as part of an interrogation and passes it on to its destination. A message to be transmitted to the ground is accepted by the transponder at the interface and is incorporated in a reply made to an interrogation.

All Mode S transmissions, uplink as well as downlink, are protected by a 24-bit parity code. The transponder performs decoding and encoding as required, so that the surveillance function as well as the message content is protected.

By keeping most data link functions separate from the basic transponder functions, the complexity of the basic transponder has been kept at the minimum required for its surveillance function. The additional complexity associated with the ground-to-air data link function is incurred only by users desiring that service.

Some Mode S transponders may be equipped with uplink and downlink message interfaces providing interaction with input/output (I/O) devices. Some transponders may include the devices as an integral part of their design.

1.5 Assumptions

This document defines the basic surveillance and data link characteristics of Mode S transponders. It is assumed that as applications of the Mode S data link mature, provisions necessary to support these applications will be designed and implemented within the system constraints set forth by this document.

1.6 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.

1.6.1 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. Test results may be used by equipment manufacturers as design guidance in preparation of installation instructions and, in certain cases, for obtaining formal approval of equipment design and manufacture.

1.6.2 Detailed Test Procedures

Detailed test procedures for hardware qualifications in ambient conditions are specified in Subsection §2.4. The test procedures contained in Subsection §2.5 verify the transponder’s surveillance and communication protocols. 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. Test results may be used by equipment manufacturers as design guidance, for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design and manufacture. Test procedures provided in §2.6 and §2.7 verify the transponder's Elementary and Enhanced Surveillance Capabilities for requirements in §2.2.24 and §2.2.25. Test procedures in §2.8 provide generic test procedures for interim use when Ground Initiated Comm-B Registers are added for requirements in §2.2.26.

1.6.3 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.

1.7 Definitions of Key Acronyms and Terms

ACAS – Airborne Collision and Avoidance System (see §A.2)
ATC – Air Traffic Control
ATCRBS – Air Traffic Control Radar Beacon System
ATIS – Automated Terminal Information System
DPSK – Differential Phase Shift Keying
ELM – Extended Length Message
Mode S – Mode Select
MTL – Minimum Triggering Level
PAM – Pulse Amplitude Modulation
PPM – Pulse Position Modulation
SPI – Special Position Identification
TCAS – Traffic Alert and Collision Avoidance System

Additional Acronyms and Definitions of Terms are provided in Appendix A.

1.8 Mode S Specific Services

Appendix C defines the functional requirements for the Mode S Specific Services, and describes the architecture within which the Mode S Specific Services entity will operate. It does not define data link applications that will be supported by Mode S and other data links.

1.9 Dataflash

Appendix C defines the requirements and test procedures for the Dataflash application.

2 MODE S TRANSPONDER EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES

2.1 General Requirements for All Equipment

2.1.1 Airworthiness

The design and manufacture of the equipment **shall** provide for installation that does not impair the airworthiness of the aircraft.

2.1.2 General Performance

The equipment **shall** perform its intended function as defined by the manufacturer, and its proper use **shall not** create a hazard to users of the National Airspace System (NAS).

2.1.3 Federal Communications Commission Rules

The equipment **shall** comply with all applicable rules of the Federal Communications Commission.

2.1.4 Fire Protection

Except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire, all materials used **shall** be self-extinguishing.

2.1.5 Operation of Controls

The operation of controls intended for use during flight, in all possible combinations and sequences, **shall not** result in a condition detrimental to the continued performance of the equipment (see §2.1.2). The operation of controls, intended for use during flight, should be designed and evaluated to ensure that they are logical and tolerant to human error. In particular, where transponder functions are integrated with other system controls, the equipment manufacturer (transponder and controls) should ensure that unintentional transponder mode switching (i.e., an operational state to 'STANDBY' or 'OFF') is minimized. This may take the form of a confirmation of mode switching, required by the flight crew. Typically 'Line Select' Keys, 'Touch Screen' or 'Cursor Controlled/Track-ball' methods used to change transponder modes should be carefully designed to minimize crew error.

All possible positions, combinations and sequences of pilot accessible controls **shall not** result in a condition detrimental to the continued performance of the equipment or continued safe flight of the aircraft.

The flight crew should be aware, at all times, of the operational state of the transponder. If either the operational state selection, or fail warning of the transponder are not visible to the flight crew, any change of the operational state of the transponder **shall** be annunciated to the flight crew via suitable means. An installation evaluation may be required to determine the adequacy of the annunciation means.

2.1.6 Accessibility of Controls

Controls that are not normally adjusted in flight **shall not** be readily accessible to flight personnel.

2.1.7 Flight Crew Control Functions

The following functions **shall** be provided.

a. A means of selecting each of the ATCRBS 4096 reply codes, and of indicating the code selected.

b. A means of selecting the air/ground state:

   1) An automatic means **shall** be the only acceptable means to determine the air/ground state.

   2) If an automatic means is not available, the transponder **shall** ensure that the air/ground state is Airborne.

c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition). Return to normal operation from this condition **shall** be possible within five seconds.

d. A means of initiating the IDENT (SPI) feature.

e. A means of inhibiting the transmission of the altitude information, while retaining the ATCRBS framing pulses in ATCRBS Mode C replies and while transmitting all ZEROs in the altitude field of Mode S replies.

f. If the aircraft uses a flight number for aircraft identification, a means **shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground, or during flight. The means for modifying and displaying aircraft identification **shall** be a simple crew action independent of the entry of other flight data.

2.1.8 Optional Crew Control Functions

On an optional basis, other functions may be provided.

2.1.9 Effects of Tests

Unless otherwise provided, the application of the specified tests **shall** produce no subsequently discernible condition detrimental to the continued performance of the equipment.

2.1.10 Equipment Configuration

It is not the intention of this performance standard to preclude manufacturers from establishing interfaces between the transponder, antenna, control panel and input/output devices and obtaining regulatory approval of these components.

Note: *For example, a transponder system with a remote control panel may have several panel configurations available to meet the needs of various aircraft types. The manufacturer is allowed to establish control panel interface standards and receive approval of the various panel designs without performing tests on the total system for each panel design.*

2.1.11 Interrogation Signals

The following paragraphs describe the signal in space as it can be expected to appear at the transponder's antenna. Because signals can be corrupted in transmission, tolerances for interrogator performance are more restrictive and should not be derived from this document. The signals in space comprise two types of interrogations distinguished by different modulation techniques: pulse amplitude modulation (PAM) and DPSK signals.

2.1.11.1 Interrogation Carrier Frequency

The carrier frequency of received interrogations is:

a. 1030 ±0.2 MHz from ATCRBS interrogators.

b. 1030 ±0.01 MHz from Mode S interrogators.

Note: *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop, but with a frequency shift of several MHz during the phase reversal.*

2.1.11.2 Measurement Convention

Pulse Amplitude is defined in relation to another pulse and is measured between pulse peaks.

Pulse Duration is measured between the half voltage points of the leading and trailing edges.

Pulse Rise Time is measured as the time interval between 10 percent and 90 percent of peak amplitude on the leading edge of the pulse.

Pulse Decay Time is measured as the time interval between 90 percent and 10 percent of peak amplitude on the trailing edge of the pulse.

Pulse-to-Pulse Intervals are measured between the half voltage points of their leading edges.

Phase Reversal Location is measured from the 90-degree point of the phase transition.

Phase Reversal Duration is measured between the 10 and 170-degree points of the transition.

Phase Reversal Intervals are measured between 90-degree points of the transitions.

2.1.11.3 Received PAM Signals

The following interrogations are exclusively PAM signals:

- ATCRBS Mode A
- ATCRBS Mode C
- ATCRBS Mode A/Mode S All-Call
- ATCRBS Mode C/Mode S All-Call
- ATCRBS Mode A-Only All-Call
- ATCRBS Mode C-Only All-Call

All of these interrogations use two or more of the four pulses shown in §2.1.11.3.2. The pulses are labeled P_1, P_2, P_3 and P_4.

2.1.11.3.1 Pulse Shapes

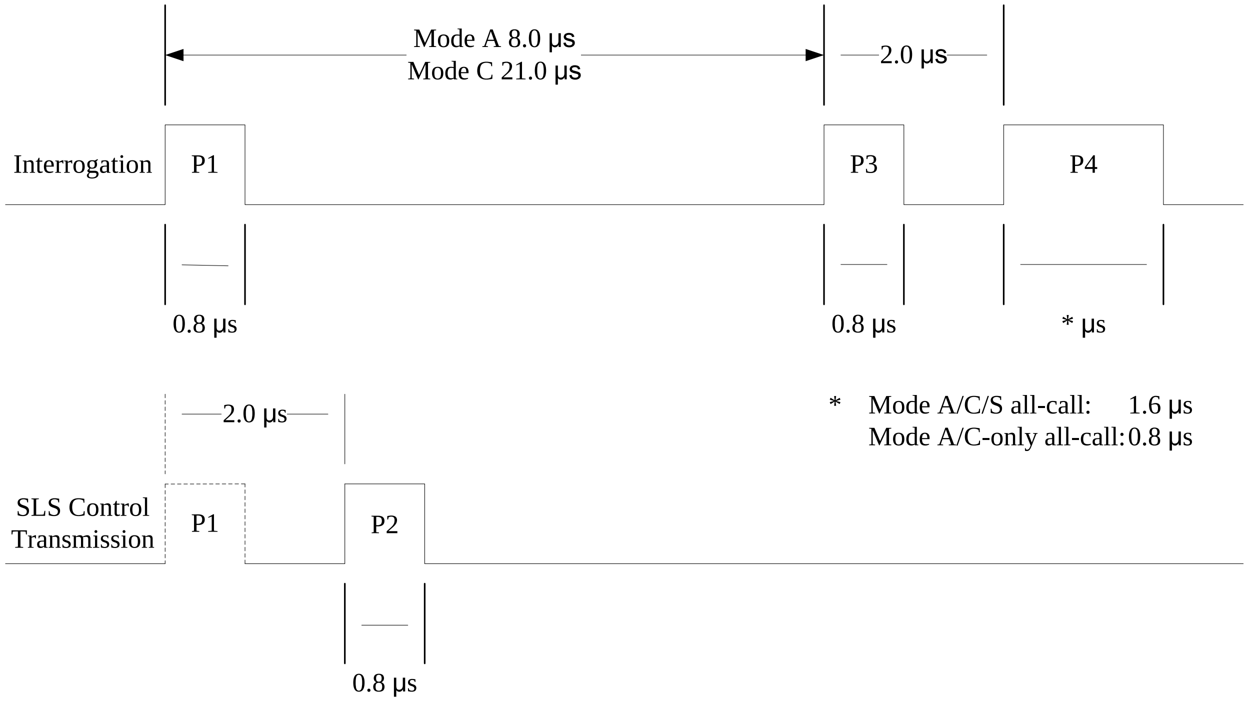
The pulse shapes for PAM interrogations are summarized below (all values are in microseconds).

Pulse Designator	Pulse Duration	Duration Tolerance	Rise Time Min/Max	Decay Time Min/Max
P_1, P_2, P_3, P_5	0.8	±0.1	0.05/0.1	0.05/0.2
P_4 (short)	0.8	±0.1	0.05/0.1	0.05/0.2
P_4 (long)	1.6	±0.1	0.05/0.1	0.05/0.2

2.1.11.3.2 Pulse Patterns

The pulse patterns of the PAM interrogations are defined as follows (all values are in microseconds).

Interrogation Type	Spacing			
	$P_1 – P_2$	$P_1 – P_3$	$P_3 – P_4$	P_4
ATCRBS Mode A	2 ±0.15	8 ±0.2	-	None
ATCRBS Mode C	2 ±0.15	21 ±0.2	-	None
ATCRBS Mode A/Mode S All-Call	2 ±0.15	8 ±0.2	2 ±0.05	Long
ATCRBS Mode C/Mode S All-Call	2 ±0.15	21 ±0.2	2 ±0.05	Long
ATCRBS Mode A-Only All-Call	2 ±0.15	8 ±0.2	2 ±0.05	Short
ATCRBS Mode C-Only All-Call	2 ±0.15	21 ±0.2	2 ±0.05	Short



<u>Figure 2-1:</u> General Pulse Patterns for PAM Interrogations

2.1.11.3.3 Relative Pulse Amplitudes

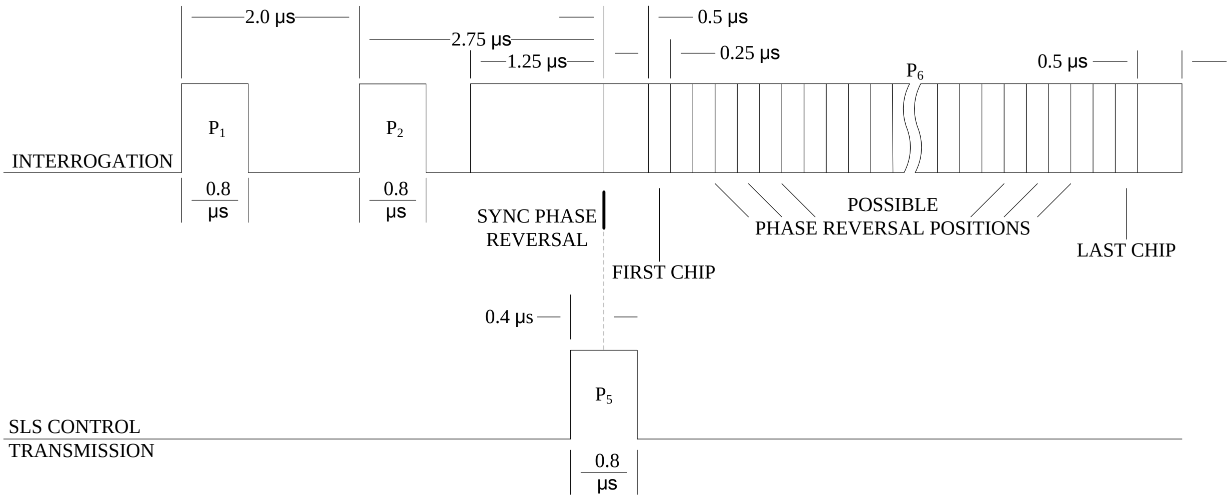
P_2 amplitudes will vary from P_1.

P_3 amplitudes are P_1 ±1 dB.

P_4 amplitudes are P_3 ±1 dB.

2.1.11.4 Received DPSK Signals

All Mode S (P_6 type) interrogations are DPSK signals. They are structured as shown in Figure 2-2.



<u>Figure 2-2:</u> General Pulse Pattern for DPSK Interrogations

<u>Note:</u> *The P_1 – P_2 pair preceding P_6 suppresses replies from ATCRBS transponders to avoid synchronous garble caused by random triggering of ATCRBS transponders by the Mode S interrogation. A series of "chips" containing the information within P_6 starts 0.5 microsecond after the sync phase reversal. A chip is an unmodulated interval of 0.25-microsecond duration preceded by possible phase reversals. If preceded by a phase reversal, a chip represents a ONE. If preceded by no phase reversal, a chip represents a ZERO. There are either 56 or 112 chips. The last chip is followed by a 0.5-microsecond guard interval which prevents the trailing edge of P_6 from interfering with the demodulation process.*

2.1.11.4.1 Pulse Shapes

Pulses P_1, P_2 and P_5 have the same shapes as pulses P_1, P_2 and P_3 of §2.1.11.3.1.

P_6 is either 16.25 ±0.25 microseconds or 30.25 ±0.25 microseconds in duration. Its rise time is between 0.05 and 0.1 microseconds, and the decay time is between 0.05 and 0.2 microseconds.

2.1.11.4.2 Relative Pulse Amplitudes

The P_2 amplitude is not more than 0.25 dB below the amplitude of P_1. The first microsecond of P_6 has amplitude not more than 0.25 dB below the amplitude of P_1. The amplitude variation of the envelope of P_6 is less than 1 dB. Amplitude variation between successive phase modulation chips in P_6 is less than 0.25 dB.

2.1.11.4.3 Phase Reversals

The first phase reversal within P_6 is the sync phase reversal. The midpoint of each following data phase reversal can occur only at a time 0.25 N ±0.02 microseconds (where N is larger than or equal to 2) after the sync phase reversal.

Note: *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop but with frequency shift during the phase reversal and slow phase reversal (80ns).*

2.1.11.4.4 Spacings

Spacings are provided below in microseconds.

$P_1 – P_2$	2.00 ±0.05
P_2 to sync phase reversal	2.75 ±0.05
P_6 to sync phase reversal	1.25 ±0.05
P_5 to sync phase reversal	0.40 ±0.05

P_5 may be overlaid on P_6 by the interrogator as an SLS signal in any Mode S interrogation. It will be overlaid on all Mode S-Only All-Call interrogations.

2.1.11.4.5 Information Content

DPSK signals contain information in data chips within P_6. The chips are located after the possible data phase reversals assigned as indicated in §2.1.11.4.3. The short or long P_6 pulses have 56 and 112 chips, respectively. A phase reversal preceding a chip characterizes that chip as ONE. No preceding phase reversal denotes a ZERO.

2.2 Minimum Performance Standards — Standard Conditions and Signals

Note: *Systems using Mode S capabilities are generally used for air traffic control surveillance systems. In addition, certain ATC applications may use Mode S emitters e.g., for vehicle surface surveillance or for fixed target detection on surveillance systems. Under such specific conditions, the term "aircraft" can be understood as "aircraft or vehicle" (A/V). While those applications may use a limited set of data, any deviation from standard physical characteristics must be considered very carefully by the appropriate authorities. They must take into account not only their own surveillance (SSR) environment, but also possible effects on other systems like TCAS.*

2.2.1 Definition of Standard Conditions

The signal levels specified in this subsection exist at the antenna end of a transponder-to-antenna transmission line of loss equal to the maximum for which the transponder is designed.

Note: *The transponder will usually be installed with less than the designed maximum transmission line loss. Nevertheless, the standard conditions of this document are based on the maximum design value.*

2.2.2 Receiver Characteristics

Note: *Although receiver characteristics for frequency and bandwidth in subparagraphs §2.2.2.1 through §2.2.2.4 are specified in terms of ATCRBS interrogations and replies, the specifications are adequate for both ATCRBS and Mode-S interrogations.*

2.2.2.1 Interrogation Tolerances

Paragraph §2.1.11 and its subparagraphs define a number of deviations allowed in the interrogation values. The transponder **shall** be tolerant to all such deviations within the ranges specified in §2.1.11.

Notes:

1. *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop, but with frequency shift during the phase reversal and slow phase reversal (80ns).*
2. *The transponder cannot make any assumption on the type of modulation technology used and therefore cannot rely on the specificities of the signal during the phase reversal to detect a phase reversal.*

2.2.2.2 Sensitivity Variation With Frequency

The RF input level required to produce 90 percent replies **shall not** vary by more than 1 dB and **shall** at no time be greater than a level of -69 dBm for standard ATCRBS interrogation signals in the frequency range between 1029.8 and 1030.2 MHz.

2.2.2.3 Bandwidth

The standard ATCRBS interrogation signal required to trigger the transponder below 1005 MHz and above 1055 MHz **shall** be at least 60 dB stronger than that required to trigger the transponder at 1030 MHz with the same reply efficiency.

Note: *There is no requirement that the 3 dB bandwidth and the skirt ratio be tested. It is known that a 3 dB bandwidth of 6 MHz and a 40 dB bandwidth of 30 MHz will be optimum for Mode S performance in the presence of ATCRBS interference and will be near optimum for ATCRBS performance.*

2.2.2.4 Sensitivity and Dynamic Range

Given an interrogation that requires a reply, the minimum triggering level (MTL) is defined as the minimum input power level that results in a 90 percent reply ratio if the interrogation signal has all nominal pulse spacings and widths and if the replies are the correct replies assigned to the interrogation format.

a. The MTL for ATCRBS and ATCRBS/Mode S All-Call interrogations **shall** be -73 dBm ±4 dB.

b. The MTL for Mode S format (P_6 type) interrogations **shall** be -74 dBm ±3 dB.

c. The reply ratio **shall** be at least 99 percent for all Mode S (P_6 type) interrogations between MTL +3 dB and -21 dBm.

d. The reply ratio **shall not** be more than 10 percent for interrogations at signal levels below -81 dBm.

e. The variation of the MTL between ATCRBS Mode A and Mode C interrogations **shall not** exceed 1 dB.

f. The reply ratio **shall** be at least 90 percent for ATCRBS and ATCRBS/Mode S All-Call interrogations between MTL +3 dB and -21 dBm.

g. The spurious ATCRBS reply ratio resulting from low level Mode-S interrogations **shall** be no more than:

   1. An average of 1% in the input interrogation signal range between -81 dBm and the Mode-S MTL, and

   2. A maximum of 3% at any given amplitude in the input interrogation signal range between -81 dBm and the Mode-S MTL.

2.2.3 Transmitter Characteristics

2.2.3.1 Reply Transmission Frequency

The carrier frequency of all downlink transmissions from transponders with Mode S capabilities **shall** be 1090 MHz plus or minus 1 MHz.

2.2.3.2 RF Peak Output Power

The RF peak output power of each pulse of each reply at the terminals of the antenna **shall** be:

a. minimum RF peak power for equipment intended for installation in aircraft that operate at altitudes not exceeding 15000 feet and that have a normal cruising speed less than 175 knots: 18.5 dBW (70 W).

b. minimum RF peak power for equipment intended for installation in aircraft that have a normal cruising speed in excess of 175 knots: 21.0 dBW (125 W).

c. minimum RF peak power for equipment intended for installation in aircraft that operate at altitudes above 15000 feet: 21.0 dBW (125 W).

d. maximum RF peak power for all equipment: 27.0 dBW (500 W).

2.2.3.3 Unwanted Output Power

When the transponder transmitter is in the inactive state, the RF output power at 1090 ±3 MHz at the terminals of the antenna **shall not** exceed -50 dBm. The inactive state is defined to include the entire period between ATCRBS and/or Mode S transmissions less 10-microsecond transition periods, if necessary, preceding and following the extremes of the transmission.

Notes:

1. *This is necessary to ensure that Mode S-equipped aircraft operating as near as 0.1 NM to an ATCRBS or Mode S sensor will not degrade the operation of that sensor. Also, an on-board 1090 MHz receiver, e.g., a collision avoidance system (CAS) installation, may be interfered with by CW radiation from the transponder. Therefore, lower unwanted CW power output may be required for use in aircraft installations where sufficient isolation cannot be achieved.*

2. *If the transponder is used in conjunction with TCAS equipment, the RF power in the inactive state at 1090 ±3 MHz at the terminals of the Mode S transponder antenna must not exceed -70 dBm in accordance with §2.2.22.f.*

2.2.3.4 Reply Rate Capability

The total reply rate over each time interval specified below **shall** be the sum of the individual ATCRBS and Mode S reply rates over this interval, and **shall** be in addition to any squitter transmissions that the transponder is required to make.

2.2.3.4.1 ATCRBS Reply Rate Capability

a. The transponder **shall** be able to continuously generate at least 500 ATCRBS 15-pulse replies per second.

b. For Class 1 equipment, the transponder **shall** be capable of a peak reply rate of 1200 ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

c. For Class 2 equipment, the transponder **shall** be capable of a peak reply rate of 1000 ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

Notes:

1. *A 15-pulse reply includes 2 framing pulses, the 12 information pulses, and the SPI pulse.*

2. *The reply rate requirement of 500 replies per second establishes the minimum continuous reply rate capability of the transponder. As per the altitude and speed criteria above, the 100 or 120 replies in a 100 millisecond interval defines the peak capability of the transponder. The transponder must be capable of replying to this short term burst rate, but may not be capable of sustaining this rate. If the transponder is subjected to interrogation rates beyond its reply rate capability, the reply rate limit control of §2.2.7.3.1 acts to gracefully desensitize the transponder in a manner that favors closer interrogators. Desensitization eliminates weaker interrogation signals.*

2.2.3.4.2 Mode S Reply Rate Capability

a. A transponder equipped for only short Mode S downlink formats (DF), **shall** have the following minimum reply rate capabilities:

50 Mode S replies in any 1-second interval.
18 Mode S replies in a 100-millisecond interval.
8 Mode S replies in a 25-millisecond interval.
4 Mode S replies in a l.6-millisecond interval.

b. A transponder equipped for long Mode S reply formats **shall** be able to transmit as long replies:

At least 16 of the 50 Mode S replies in any 1-second interval.
At least 6 of the 18 Mode S replies in a 100-millisecond interval.
At least 4 of the 8 Mode S replies in a 25-millisecond interval.
At least 2 of the 4 Mode S replies in a l.6-millisecond interval.

c. A transponder equipped with the enhanced data link protocols (see §2.2.21) **shall** be able to transmit as long replies:

At least 24 of the 50 Mode S replies in any 1-second interval.
At least 9 of 18 Mode S replies in a 100-millisecond interval.
At least 6 of 8 Mode S replies in a 25 millisecond interval.
At least 2 of 4 Mode S replies in a 1.6 millisecond interval.

All of the above reply rates **shall** be in addition to any squitter transmissions that the transponder is required to make.

Note: *Higher reply rates are required by a TCAS-compatible transponder (see §2.2.22.b).*

2.2.3.5 Mode S ELM Peak Reply Rate

At least once every second, a transponder equipped for ELM downlink operation **shall** have the capability of transmitting, in a 25-millisecond interval, 25 percent more segments than have been announced in the initialization.

Note: *Transponders may exist which are capable of transmitting less than the maximum allowable number of Comm-D segments in one burst. The requirement for 25 percent surplus transmitting capacity is derived from the possible need for reinterrogation.*

2.2.4 Reply Pulse Characteristics

The signals in space comprise two types of replies distinguished by different modulation techniques: PAM and PPM signals.

2.2.4.1 ATCRBS Replies

2.2.4.1.1 Framing Pulses

The reply function **shall** use two framing pulses nominally spaced 20.3 microseconds apart.

2.2.4.1.2 Information Pulses

The designators of the information pulses and their positions from the first framing pulse **shall** be:

PULSE	POSITION (in microseconds)
Cl	1.45
Al	2.90
C2	4.35
A2	5.80
C4	7.25
A4	8.70
X*	10.15
Bl	11.60
Dl	13.05
B2	14.50
D2	15.95
B4	17.40
D4	18.85

* The X pulse is referenced here for possible future use (see §2.2.13.1.2).

2.2.4.1.3 ATCRBS-SPI

In addition to the information pulses provided, an SPI pulse, which may be used with any of the other information pulses upon request, **shall** be provided at a spacing of 4.35 microseconds following the last framing pulse. The SPI pulse **shall** be initiated by an IDENT switch. Upon activation of the IDENT switch, the SPI pulse **shall** be transmitted when replying to ATCRBS Mode A interrogations for a period of 18 ±1.0 seconds. The SPI pulse **shall** be transmitted only if the IDENT switch is first activated. The SPI pulse **shall not** be transmitted when replying to Mode C interrogations.

2.2.4.1.4 ATCRBS Reply Pulse Shape

All reply pulses and SPI pulses **shall** be 0.45 ±0.10 microsecond duration and have rise times of from 0.05 to 0.1 microseconds and decay times of from 0.05 to 0.2 microseconds. The rise and decay time may be less, providing the sideband radiation is no greater than that which would be produced theoretically by a trapezoidal wave having the stated rise and decay time. The Mode S reply spectrum requirement of §2.2.4.2.3.d is an acceptable specification for meeting ATCRBS minimum rise and fall time requirements.

The pulse amplitude variation of one pulse, with respect to any other pulse in a reply train, **shall not** exceed l dB.

Note: *The above characteristics for ATCRBS reply pulse shapes are compatible with characteristics for Mode S reply pulse shapes (see §2.2.4.2.3).*

2.2.4.1.5 ATCRBS Reply Pulse Spacing Tolerance

The pulse spacing tolerances for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group **shall** be ±0.10 microsecond. The pulse spacing tolerance of the SPI pulse with respect to the last framing pulse of the reply group **shall** be ±0.10 microsecond. The pulse spacing tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) **shall** be no more than ±0.15 microsecond.

2.2.4.1.6 ATCRBS Reply Delay and Jitter

a. At all RF input levels from MTL to -21 dBm, the time delay between the arrival at the transponder input of the leading edge of P_3 and the transmission of the leading edge of the first pulse of the reply **shall** be 3.0 ±0.5 microseconds.

b. At all RF input levels from 3 dB above MTL to -21 dBm, the jitter at the leading edge of the first pulse of the reply with respect to P_3 **shall not** exceed ±0.1 microsecond.

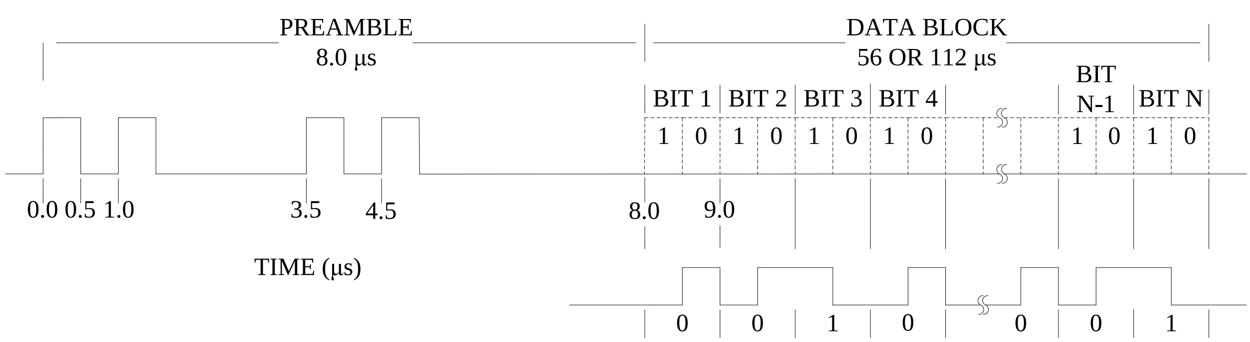
c. At all RF input levels from 3 dB above MTL to -21 dBm, the time delay variations between ATCRBS modes **shall not** exceed 0.2 microseconds.

2.2.4.2 Mode S Replies

The reply data block is formed by PPM encoding of the reply data. A pulse transmitted in the first half of the interval represents a ONE while a pulse transmitted in the second half represents a ZERO (see Figure 2-3).

2.2.4.2.1 Mode S Preamble

The preamble **shall** consist of 4 0.5 ±0.05 microsecond pulses. The second, third and fourth pulses **shall** be spaced 1.0, 3.5 and 4.5 microseconds, respectively, from the first transmitted pulse. The spacing tolerance **shall** be in accordance with §2.2.4.2.4.



Example: Reply Data Block Waveform Corresponding to bit sequence 0010...001

<u>Figure 2-3:</u> Mode S Reply Waveform

2.2.4.2.2 Mode S Data Pulses

The block of reply data pulses **shall** begin 8.0 microseconds after the first transmitted pulse. Either 56 or 112 1-microsecond intervals **shall** be assigned to each transmission. A pulse with a width of 0.5 ±0.05 microsecond **shall** be transmitted either in the first or the second half of each interval. If a pulse transmitted in the second half of one interval is followed by another pulse transmitted in the first half of the next interval, the two pulses **shall** merge and a 1.0 ±0.05 microsecond pulse **shall** be transmitted.

2.2.4.2.3 Mode S Reply Pulse Shape

a. The pulse amplitude variation between one pulse and any other pulse in a reply **shall not** exceed 2 dB.

b. The pulse rise time **shall not** exceed 0.1 microseconds.

c. The pulse decay time **shall not** exceed 0.2 microseconds.

d. The spectrum of a reply **shall not** exceed the following bounds:

Frequency Difference (MHz From Carrier)	Maximum Relative Response (dB Down From Peak)
≥ 1.3 and < 7	3
≥ 7 and < 23	20
≥ 23 and < 78	40
≥ 78	60

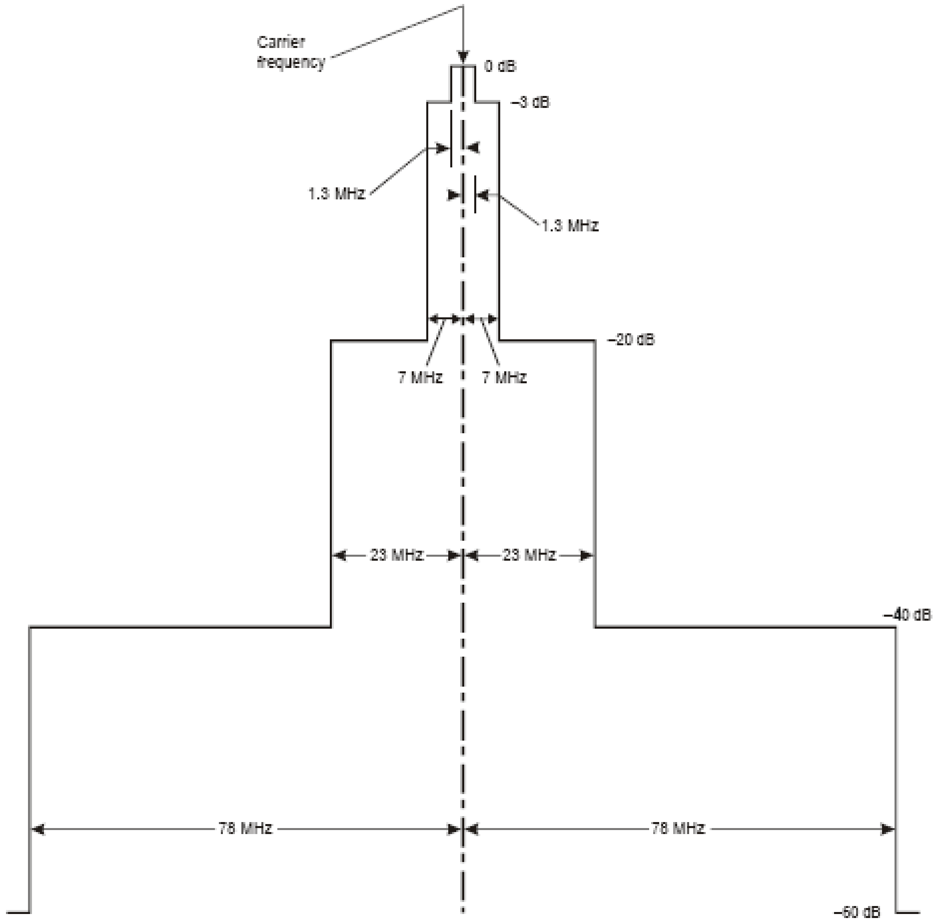


Figure 2-4: Spectrum Limits for Mode S Transponder Transmitter

2.2.4.2.4 Mode S Reply Pulse Spacing Tolerance

Mode S reply pulses **shall** start at a defined multiple of 0.5 microseconds from the first transmitted pulse. The pulse position tolerance **shall** be ±0.05 microseconds, measured from the first pulse of the reply.

2.2.4.2.5 Mode S Reply Delay and Jitter

a. At all RF input levels from MTL to -21 dBm, the first preamble pulse of the reply **shall** occur 128 ±0.25 microseconds after the sync phase reversal of the received P_6 of a Mode S interrogation. At all RF input levels from MTL to -21 dBm, the jitter of the reply delay **shall not** exceed ±0.08 microsecond, peak (99.9 percentile).

b. At all RF input levels from MTL to -21 dBm, the first preamble pulse of the reply **shall** occur 128 ±0.5 microseconds after the leading edge of the P_4 pulse of the ATCRBS/Mode S All-Call interrogation. At all RF input levels from MTL +3 dB to -21 dBm, the jitter of the reply delay **shall not** exceed ±0.1 microsecond, peak (99.9 percentile).

2.2.5 Side Lobe Suppression Characteristics

Side lobe suppression is accomplished separately for ATCRBS, ATCRBS-Only All-Call, ATCRBS/Mode S All-Call and for Mode S format interrogations.

2.2.5.1 Side Lobe Suppression, ATCRBS, ATCRBS-Only All-Call, and ATCRBS/Mode S All-Call

The transponder **shall** react to side lobe interrogations as follows:

a. Conditions Under Which the Transponder **SHALL** Be Suppressed

The transponder **shall** reply to no more than one percent (1%) of the interrogations under all combinations of the following conditions:

(1) when the pulse interval between P_1 and P_2 is varied over the range from 1.85 to 2.15 microseconds,

(2) when the RF input signal level of P_1 is varied from 3 dB above MTL to -21 dBm,

(3) when the level of P_2 equals or exceeds the level of P_1.

b. Conditions Under Which the Transponder **SHALL NOT** Be Suppressed

The transponder **shall** reply to at least 90 percent of the interrogations over the input signal level range of 3 dB above MTL to -21 dBm, when:

(l) the level of P_1 exceeds the level of P_2 by 9 dB or more,

(2) no pulse is received at the position 2.0 ±0.7 microseconds following P_1,

(3) the duration of P_2 is less than 0.3 microsecond.

c. Conditions Under Which Transponder **SHALL NOT** Reply but May Initiate Suppression

The transponder **shall not** reply with more than 10 percent reply ratio over the RF input level range from MTL to MTL +3 dB, if the amplitude of P_2 equals or is greater than the amplitude of P_1. Under the same conditions, the transponder may or may not initiate suppression.

d. Side Lobe Suppression Characteristics

(1) The suppression duration is defined as the time between the P_2 pulse initiating the suppression and the P_1 pulse of the earliest subsequent interrogation to which the transponder replies. The duration **shall** be between 25 and 45 microseconds for all ATCRBS and ATCRBS/Mode S All-Call modes.

(2) The side lobe suppression period **shall** begin after receipt of the leading edge of P_2.

(3) The side lobe suppression period **shall** be capable of being reinitiated within two microseconds after the end of any suppression period.

(4) The receiver sensitivity for ATCRBS signals **shall** be at MTL not later than one microsecond after the end of the suppression period.

(5) The two-pulse sidelobe suppression pair **shall** initiate ATCRBS suppression in a Mode S transponder regardless of the position of the pulse pair in a group of pulses, provided the transponder is not already suppressed or in a transaction cycle (see §2.2.18.2.2.k.).

Note: *The P_3 – P_4 pair of the ATCRBS-Only All-Call interrogation both prevents a reply and initiates suppression. Likewise, the P_1 – P_2 preamble of a Mode S interrogation initiates suppression independently of the waveform that follows it.*

2.2.5.2 Side Lobe Suppression, Mode S Formats

Side lobe suppression for Mode S formats is characterized by the reception of P_5, overlaying the location of the sync phase reversal of P_6.

Given an interrogation which would otherwise require a reply, the transponder **shall**:

a. at all signal levels between MTL +3 dB and -21 dBm, have a reply ratio of less than 10 percent if the received amplitude of P_5 exceeds the received amplitude of P_6 by 3 dB or more;

b. at all signal levels between MTL +3 dB and -21 dBm, have a reply ratio of at least 99 percent if the received amplitude of P_6 exceeds the received amplitude of P_5 by 12 dB or more.

2.2.6 Pulse Decoder Characteristics

Unless otherwise specified, the following pulse decoder characteristics **shall** apply over the RF input signal level range from MTL +1 dB to -21 dBm and nominal interrogation signal characteristics. Applicable “valid” interrogations **shall** result in at least 90 percent replies, and interrogations which are not valid **shall** result in less than 10 percent replies.

2.2.6.1 Pulse Level Tolerances

2.2.6.1.1 ATCRBS/Mode S All-Call

If the equipment receives a valid ATCRBS interrogation at any signal level from MTL +1 dB to -21 dBm followed by a 1.6 microsecond pulse in the P_4 position:

a. it **shall** accept the interrogation as an ATCRBS/Mode S All-Call interrogation if the received amplitude of P_4 is above the amplitude of P_3 minus 1 dB;

b. it **shall** accept the interrogation as an ATCRBS interrogation if the received amplitude of P_4 is below the amplitude of P_3 minus 6 dB.

2.2.6.1.2 ATCRBS-Only All-Call

If the equipment receives a valid ATCRBS interrogation at any signal level from MTL +1 dB to -21 dBm followed by a 0.8 microsecond pulse in the P_4 position:

a. it **shall** accept the interrogation as an ATCRBS interrogation if the received amplitude of P_4 is below the amplitude of P_3 minus 6 dB;

b. it **shall not** accept the interrogation if the received amplitude of P_4 is above P_3 minus l dB.

Note: *Mode S transponders do not accept the ATCRBS-Only All-Call.*

2.2.6.2 Pulse Position Tolerances

a. The equipment **shall** accept the pulse position of ATCRBS interrogations as valid if the spacing between P_1 and P_3 is within plus or minus 0.2 microsecond of the nominal spacing.

   The transponder **shall** accept the pulse position of ATCRBS/Mode S All-Calls as valid if the spacing between P_1 and P_3 is within plus or minus 0.2 microsecond of the nominal spacing, and if the spacing between P_3 and P_4 is within plus or minus 0.05 microsecond of nominal.

b. The transponder **shall not** accept the pulse position of ATCRBS, ATCRBS/Mode S All-Call and ATCRBS-Only All-Call interrogations as valid if the spacing between P_1 and P_3 differs from the nominal spacing by 1.0 microsecond or more.

c. The transponder **shall not** accept an interrogation as an ATCRBS/Mode S All-Call if the leading edge of P_4 is not detected within the interval from 1.7 to 2.3 microseconds following the leading edge of P_3.

2.2.6.3 Pulse Duration Tolerances

a. The transponder **shall** accept the pulses of an ATCRBS interrogation as valid if the duration of both P_1 and P_3 is between 0.7 and 0.9 microsecond.

   The transponder **shall** accept an ATCRBS/Mode S All-Call interrogation as valid if the duration of both P_1 and P_3 is between 0.7 and 0.9 microsecond and if the duration of P_4 is between 1.5 and 1.7 microseconds.

b. The transponder **shall not** accept an ATCRBS/Mode S All-Call interrogation as valid if the duration of the P_4 pulse is outside of the range between 1.2 and 2.5 microseconds.

c. For all signal levels from MTL to -45 dBm, the transponder **shall** accept no more than 10 percent of ATCRBS or ATCRBS/Mode S All-Call interrogations if the duration of either the P_1 pulse or the P_3 pulse is less than 0.3 microseconds.

2.2.6.4 Sync Phase Reversal Position Tolerance

The transponder **shall** determine the location of the sync phase reversal relative to either the leading edge of P_2 or the leading edge of P_6. If the transponder determines the sync phase reversal from P_2, the sync phase reversal **shall** be accepted if it is received within the interval from 2.7 to 2.8 microseconds following the leading edge of P_2. The sync phase reversal **shall** be rejected if it is received outside of the interval from 2.55 to 2.95 microseconds following the leading edge of P_2. In the gray zones between these limits (that is, in the zone from 2.55 to 2.7 microseconds and in the zone from 2.8 to 2.95 microseconds) the transponder may or may not accept the sync phase reversal. If the transponder determines the sync phase reversal from P_6, the sync phase reversal **shall** be accepted if it is received within the interval from 1.2 to 1.3 microseconds following the leading edge of P_6. The sync phase reversal **shall** be rejected if it is received outside of the interval from 1.05 to 1.45 microseconds following the leading edge of P_6. In the gray zones between these limits (that is, in the zone from 1.05 to 1.2 microseconds and in the zone from 1.3 to 1.45 microseconds) the transponder may or may not accept the sync phase reversal.

2.2.7 Desensitization and Recovery Characteristics

2.2.7.1 Echo Suppression

2.2.7.1.1 Echo Suppression Desensitization

Upon receipt of any pulse more than 0.7 microsecond in duration (desensitization pulse), the transponder **shall** be desensitized temporarily for all received signals by raising the receiver threshold. Immediately after the desensitization pulse, the receiver threshold **shall** be between the level of the desensitization pulse and 9 dB below that, except for a possible overshoot during the first microsecond following the desensitization pulse.

2.2.7.1.2 Narrow Pulse Performance

Single pulses less than 0.7 microsecond in duration are not required to cause a specified desensitization, but if they occur **shall not** cause a desensitization of amplitude or duration greater than that permitted in §2.2.7.1.1 and §2.2.7.2.

2.2.7.2 Recovery

Following desensitization, the receiver **shall** recover sensitivity within 3 dB of MTL, within 15 microseconds after reception of the trailing edge of a desensitizing pulse having a signal strength up to 50 dB above MTL. Recovery **shall** be at an average rate not exceeding 4.0 dB per microsecond.

2.2.7.2.1 Recovery From a Mode S Interrogation If No Reply Is Required

Following a correctly addressed Mode S interrogation which has been accepted and which requires no reply, a transponder **shall** recover sensitivity to within 3 dB of MTL no later than 45 microseconds after receipt of the sync phase reversal.

2.2.7.2.2 Recovery From a Suppression Pair

The receipt of P_1 and P_2 suppression pulses may temporarily desensitize the transponder according to §2.2.7.1.1, but the suppression pairs **shall not** otherwise interfere with the reception of Mode S interrogations.

2.2.7.2.3 Recovery From a Mode S Interrogation Which Has Not Been Accepted

Following a Mode S interrogation that has not been accepted, the transponder **shall** recover sensitivity to within 3 dB of MTL no later than 45 microseconds after receipt of the sync phase reversal.

2.2.7.2.4 Recovery From Unaccepted ATCRBS/Mode S and ATCRBS-Only All-Calls

Following unaccepted ATCRBS/Mode S or ATCRBS-Only All-Calls, the transponder **shall** recover sensitivity according to §2.2.7.2.

2.2.7.2.5 Dead Time

The time interval beginning at the end of a reply transmission and ending when the receiver has regained its sensitivity to within 3 dB of MTL **shall not** exceed 125 microseconds.

Note: *Dead time should be minimized to maximize system reliability.*

2.2.7.3 Reply Rate Limiting

Reply rate limiting in a Mode S transponder **shall** be separate and independent for Mode S and ATCRBS replies.

2.2.7.3.1 ATCRBS Reply Rate Limiting

A sensitivity-reduction reply rate limit **shall** be incorporated in the transponder for ATCRBS replies. The limit **shall** be capable of being adjusted between 500 continuous ATCRBS Mode A and Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 2000 replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction **shall** apply only to the receipt of ATCRBS, ATCRBS/Mode S All-Call, and ATCRBS-Only All-Call interrogations.

2.2.7.3.2 Mode S Reply Rate Limiting

If a reply rate limiting device is provided for Mode S replies, it **shall** permit at least the reply rates required in §2.2.3.4.2. A limiting device may be used to protect the transponder from accidental over-interrogation.

2.2.8 Response in the Presence of Interference

2.2.8.1 Response in the Presence of Low Level Asynchronous Interference

For all received signal levels between -65 and -21 dBm, given an interrogation that requires a reply according to §2.2.17 and if no lockout condition is in effect, the transponder **shall** reply correctly with at least 95 percent reply ratio in the presence of asynchronous interference.

Asynchronous interference consists of single 0.8 microsecond pulses with carrier frequency of 1030 ±0.2 MHz, incoherent with the Mode S signal carrier frequency and occurring at all repetition rates up to 10000 Hz at a level 12 dB or more below the level of the Mode S signal.

Note: *Such pulses may combine with P_1 and P_2 pulses of the Mode S wave form to form a valid ATCRBS-Only All-Call wave form. The Mode S transponder does not respond to ATCRBS-Only All-Calls. A preceding pulse may also combine with the P_2 of the Mode S waveform to form a valid Mode A or Mode C wave form. Under such conditions, the P_1 – P_2 pair of the Mode S preamble takes precedence.*

2.2.8.2 Response in the Presence of a Standard Interfering Pulse

A standard interfering pulse is defined as a 0.8 microsecond pulse with a carrier frequency of 1030 ±0.2 MHz that is incoherent with the Mode S signal of the test and that overlaps the P_6 of the Mode S interrogation anywhere after the sync phase reversal.

Given an interrogation that requires a reply, the reply ratio of a transponder **shall** be at least 95 percent if the level of the interfering pulse is 6 dB or more below the signal level for input signal levels between -68 and -21 dBm.

Under the same conditions, the reply ratio **shall** be at least 50 percent if the interference pulse level is 3 dB or more below the signal level.

Note: *This measurement simulates the overlay of ATCRBS pulses over the DPSK modulation of the Mode S interrogation and assures that the demodulation scheme of the transponder is effective. Designs such as narrow band filters that merely detect the occurrence of a phase change will not perform satisfactorily.*

2.2.8.3 Response in the Presence of Pulse Pair Interference

The interfering signal **shall** consist of P_1 and P_2, spaced 2 microseconds apart, with a carrier frequency of 1030 ±0.2 MHz, that is incoherent with the Mode S signal of the test. The interfering pulse pair **shall** overlay any part of the Mode S interrogation except that the leading edge of the P_1 interfering pulse **shall** occur no earlier than the P_1 pulse of the Mode S signal. Given an interrogation that requires a reply, the reply ratio of a transponder **shall** be at least 90 percent if the level of the interfering signal is 9 dB or more below the signal levels for signal level inputs between -68 and -21 dBm.

Note: *This assures that Mode S decoding is not inhibited by the receipt of ATCRBS side lobe suppression pulse pairs.*

2.2.8.4 Response in the Presence of TACAN/DME and JTIDS Interference

Given a Mode S interrogation that requires a reply, the reply ratio of the transponder **shall** be at least 90 percent for input signal levels between -68 and -21 dBm when either of the following signals is applied with the interrogation signal:

a. A TACAN/DME signal at a nominal repetition rate of 3600 pulse pairs per second for both X and Y (12 and 30 microseconds) channel pulse spacings, at a level of -30 dBm, and over the frequency ranges of 962-1020 and 1041-1213 MHz.

b. A single pulse with a duration of 6.4 microseconds at a rate of 2000 pulses per second, at a level of -80 dBm and a frequency of 1030 MHz.

2.2.8.5 Simultaneous Interrogation of Mode A and Mode C

If a transponder receives two valid ATCRBS pulse patterns simultaneously, it **shall**:

a. Enter the ATCRBS suppression state if one of the received pulse patterns is a $P_1 – P_2$ suppression pair.

b. Generate a valid Mode C reply if the two received pulse patterns are Mode A and Mode C interrogations.

Note: *Simultaneous receipt of two interrogation pulse patterns can occur wherever there are two or more interrogators transmitting in the same airspace. For example, a single pulse from an interfering interrogator received 8 or 21 microseconds before the second pulse of a $P_1 – P_2$ pair can cause the transponder to simultaneously recognize an ATCRBS interrogation and an ATCRBS suppression. When this occurs, the Mode S transponder should enter the ATCRBS suppression state. It will thereby be enabled to receive the remainder as a possible interrogation waveform following the $P_1 – P_2$ pair. A single interference pulse received 8 microseconds before the P_3 pulse of a Mode C interrogation (or 21 microseconds before the P_3 pulse of a Mode A interrogation) can cause the transponder to simultaneously recognize both interrogation patterns. When this occurs, a Mode C reply is preferred because a missing Mode A reply usually causes less degradation of beacon tracking.*

2.2.8.6 Response in the Presence of CW Interference

In the presence of non-coherent CW interference at a frequency of 1030 ±0.2 MHz, at signal levels of 20 dB or more below the desired ATCRBS or Mode S interrogation signal level, the transponder **shall** reply correctly to at least 90 percent of the interrogations.

2.2.8.7 Compatibility with TCAS ATCRBS Surveillance

With P_1 at MTL and S_1 at MTL -6 dB, the transponder **shall** reply to ATCRBS interrogations at least 90 % of the time.

With P_1 at MTL and S_1 at MTL -3 dB, the transponder **shall** reply to ATCRBS interrogations at least 70 % of the time.

With P_1 at MTL and S_1 at MTL, the transponder **shall** reply to no more than 10% of ATCRBS interrogations.

Note: *S_1 is equal to P_1 in duration with the leading edge of S_1 being 2.0 microseconds ahead of the leading edge of P_1. Amplitude of S_1 is varied relative to P_1 as indicated above.*

2.2.9 Undesired Replies

2.2.9.1 ATCRBS

a. The random trigger rate squitter on all ATCRBS modes **shall not** be greater than 5 reply pulse groups or suppressions per second, averaged over a period of at least 30 seconds.

b. The random trigger rate on all ATCRBS modes **shall not** be greater than 10 reply pulse groups or suppressions per second, averaged over a period of 30 seconds, when operated in the presence of non-coherent CW interference at a frequency of 1030 ±0.2 MHz and at signal levels of -60 dBm or less.

2.2.9.2 Mode S

a. In the absence of valid interrogation signals, Mode S transponders **shall not** generate unwanted Mode S replies more often than once per 10 seconds.

b. In the presence of non-coherent CW interference at a frequency of 1030 ±0.2 MHz and at signal levels of -60 dBm or less, and in the absence of valid interrogation signals, Mode S transponders **shall not** generate unwanted Mode S replies more often than once per 10 seconds.

2.2.10 Self Test and Monitor(s)

2.2.10.1 Self Test

If a self-test feature or monitor is provided as a part of the equipment:

a. The device that radiates test interrogation signals or prevents transponder reply to proper interrogation during the test period **shall** be limited to intermittent use for no longer than that required to determine the transponder status. The test interrogation rate for ATCRBS and ATCRBS-Only All-Call interrogations **shall** be 235 ±5 interrogations per second or a sub-multiple thereof. Test interrogations using Mode S formats, including ATCRBS/ Mode S All-Call, **shall not** exceed one of each format for which the transponder is equipped in any given test sequence.

b. The self-test interrogation signal level at the antenna end of the transmission line **shall not** exceed -40 dBm.

c. If provision is made for an automatic periodic self-test procedure, such self testing **shall not** radiate replies at an average rate exceeding one reply every ten seconds.

2.2.10.2 Squitter Monitor

A squitter monitor **shall** be provided to verify that the Mode S transponder generates short and Extended Squitters at their nominal rates (see §2.2.18.2.6 and §2.2.23.1). Event-Driven Squitter rates are not required to be monitored to meet this requirement. The transponder **shall** be considered failed when the monitor has detected squitter failure.

2.2.10.3 Mode S Address Verification

The Mode S transponder **shall** declare a transponder failure in the event that its own Mode S address is ALL ZEROs or ALL ONEs.

2.2.10.4 Failure Annunciation

An output **shall** be provided to indicate the validity/non-validity of the transponder. Failure to generate squitters at the nominal rate, a failure detected by self-test or the monitoring function, or failure of Mode S address verification **shall** cause the output to assume the invalid state. Momentary power interrupts **shall not** cause the output to assume the invalid state. The status of the transponder **shall** be annunciated to the flight crew.

2.2.11 Response to Mutual Suppression Pulses

a. If the equipment is designed to accept and respond to mutual suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment **shall** regain normal sensitivity, within 3 dB, not later than 15 microseconds after the end of the applied mutual suppression pulse.

   Note: *This document does not establish the design parameters of the mutual suppression system. However, it is recommended that all sources of mutual suppression pulses be DC coupled while sinks are AC coupled. This standardization will prevent source or sink failures from disabling all users of the mutual suppression pulses.*

b. The suppression output signal **shall** precede the transponder RF transmission by no more than 10 microseconds and return to the inactive state in less than 10 microseconds.

2.2.12 Diversity Operations

Diversity Mode S transponders may be implemented for the purpose of improving air-to-air surveillance and communications. Such systems **shall** employ two antennas, one mounted on the top and the other on the bottom of the aircraft. Appropriate switching and signal processing channels to select the best antenna on the basis of the characteristics of the received interrogation signals **shall** also be provided. Such diversity systems, in their installed configuration, **shall not** result in degraded performance relative to that which would have been produced by a single system having a bottom-mounted antenna.

Note: *TCAS operations require diversity operations. The use of diversity is highly recommended for any transponder installation.*

2.2.12.1 Diversity Antenna Selection and Selection Threshold

a. Diversity Antenna Selection

Antenna selection **shall** be automatic. The transponder **shall** select one of the two antennas on the basis of the relative strengths of the detected interrogation signals, provided that both channels simultaneously receive a valid identical interrogation or pulse pair. Antenna selection and switching may occur after the receipt of one of the following.

(1) The P_3 pulse of a $P_1 – P_3$ pulse pair, indicating an ATCRBS or ATCRBS/Mode S All-Call interrogation.

(2) The P_2 pulse of a $P_1 – P_2$ pulse pair, indicating a possible Mode S preamble.

(3) The first microsecond of P_6 of a Mode S interrogation.

(4) A complete, error-free Mode S interrogation.

The selected antenna **shall** be used to receive the remainder of the interrogation and, if necessary, to transmit the Mode S or ATCRBS reply.

b. Selection Threshold

The transponder **shall** nominally select the antenna connected to the RF port having the stronger signal. To allow for unbalance in the characteristics of the two channels, a transition zone ±3 dB wide is permitted, in which either antenna may be selected.

Additional selection can be made based on the correctness of a received complete Mode S interrogation. In this case, the RF port having the correct signal will be selected. If correctness is observed in both channels, selection **shall** be based on relative signal strength. This additional selection criterion is an optional feature.

2.2.12.2 Received Signal Delay Tolerance

If an interrogation is received at either antenna 0.125 microseconds or less in advance of reception at the other antenna, the interrogations **shall** be considered simultaneous and the reply antenna selection criteria **shall** be applied. If an interrogation is received at either antenna 0.375 microseconds or more in advance of reception at the other antenna, the antenna selected for the reply **shall** be the one which received the earlier interrogation. If the relative time of receipt is between 0.125 and 0.375 microseconds, the transponder **shall** select the reply antenna based on either the simultaneous interrogation criteria or the earlier time of arrival.

2.2.12.3 Diversity Transmission Channel Isolation

The peak RF power transmitted from the selected antenna **shall** exceed the power transmitted from the non-selected antenna by at least 20 dB.

2.2.12.4 Reply Delay of Diversity Transponders

The total difference in mean reply delay between the two antenna channels (including the transponder to antenna cables) **shall not** exceed 0.08 microseconds for interrogations of equal amplitude. This requirement is applicable to interrogation signal strengths between MTL +3 dB, and -21 dBm.

Note: *This requirement limits apparent jitter caused by diversity operation and by cable delay differences. The jitter requirements on each individual channel remain as specified for non-diversity transponders. Control of apparent jitter caused by antenna location is specified in §3.1.6.c.*

2.2.12.5 Squitter Antenna Selection

2.2.12.5.1 Acquisition Squitter

Transponders operating with antenna diversity (see §2.2.19.3.1) **shall** transmit acquisition squitters as follows:

a. When in the derived airborne state, the transponder **shall** transmit acquisition squitters alternately from the two antennas; and

b. When in the derived on-the-ground state, the transponder **shall** transmit acquisition squitters under control of the SAS subfield (see §2.2.23.1.7). In the absence of any SAS commands, use of the top antenna only **shall** be the default condition.

Notes:

1. *The acquisition squitter is suppressed by aircraft that automatically determine the on-the-ground state when the aircraft is declaring the on-the-ground state (Table 2-2, §2.2.23.1.5).*

2. *"Derived" signifies the state resulting from the strut switch input, or any other input parameters that can be used to determine airborne or on-ground status (see §2.2.18.2.7.c).*

2.2.12.5.2 Extended Squitter

Transponders operating with antenna diversity (see §2.2.19.3.1) **shall** transmit Extended Squitters as follows:

a. When broadcasting the airborne type formats, the transponder **shall** transmit each type of Extended Squitter alternately from the two antennas; and

b. When broadcasting the surface type formats (see §2.2.23.1.2.b), the transponder **shall** transmit Extended Squitters under control of the SAS subfield (see §2.2.23.1.7.3). In the absence of any SAS commands, use of the top antenna only **shall** be the default condition.

2.2.13 Data Handling and Interfaces

2.2.13.1 Direct Data[2]

Direct data are those which are part of the Mode S system surveillance protocol.

2.2.13.1.1 Fixed Direct Data

Fixed direct data characterize the aircraft.

a. Mode S Discrete Address

(1) Protection of Mode S address bits – During the power-on initialization process, the transponder **shall** read in and store its 24-bit discrete address. Thereafter, the address used by the transponder **shall not** change from the value stored at power-up. The transponder should continue to monitor the 24-bit discrete address after the initial read and store at power-up. If a change in the 24-bit discrete address is detected after the initial read and store, the transponder **shall** continue to use only the 24-bit discrete address stored at power-up and **shall** generate a diagnostic error message in order to alert maintenance personnel to the occurrence of intermittent discrete address bit input data. If the transponder 24-bit discrete address is set to ALL ONEs or ALL ZEROs at startup, then this error condition **shall** be indicated to the pilot, and the transponder **shall** either transition to Standby State, Power Off Condition, or operate as a pure Mode A/C Transponder.

Notes:

1. *This last requirement is imposed to specifically disallow Mode S transponders from operating with invalid addresses. This condition has been observed in airspace operations and it poses a number of unsafe conditions.*
2. *If there is no other Mode S transponder active (not in Standby or a Failed condition), then TCAS will declare a "TCAS System Fail" or enter the "Standby" condition (see §2.2.22.5).*
3. *If this condition occurs at startup, then the transponder should be deactivated until the condition is corrected, or only be able to operate in pure Mode A/C only. "Pure" Mode A/C Transponders (in accordance with RTCA DO-144A or later version) reply to all $P_1 – P_3$ and $P_1 – P_3 – P_4$ interrogations with a Mode A/C reply and do not transmit any squitter.*
4. *Accommodation should be made for those military transponders that have the capability to change the 24-bit address (e.g., so the aircraft can operate as a State aircraft with a corresponding address, or as a NATO aircraft with a NATO address). However, under no conditions may such a transponder operate as a Mode S transponder if the address is invalid.*

(2) Mode S-Only All-Call Replies – In response to a Mode S-Only All-Call interrogation, the transponder **shall** place its 24-bit discrete address in the "AA" field (see §2.2.14.4.1), bits 9-32 of the All-Call reply.

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[2] Data fields referred to here are defined in §2.2.14.

(3) All Other Mode S Transmissions – In each response to any Mode S interrogation except Mode S-Only All-Call, the transponder **shall** place its 24-bit address, overlaid on parity, in the "AP" field, bits 33-56 of short formats and bits 89-112 of long formats (see §2.2.14.4.4).

b. Maximum Airspeed

In response to certain surveillance interrogations, the transponder **shall** place an encoded indication of the aircraft's maximum normal operating airspeed into bits 14-17 of the RI field. Coding is described in §2.2.14.4.33.

c. Aircraft Identification Data

If the tail number or registration number of the aircraft is used to identify the aircraft for ATC purposes, it constitutes "fixed" data. If the aircraft uses a flight number in lieu of a registration number, then the data are no longer "fixed," but classified as "variable" (see §2.2.13.1.2).

If not equipped with the aircraft identification data capability, the transponder **shall** insert ZEROs into the appropriate field.

2.2.13.1.2 Variable Direct Data

Variable direct data characterize the flight condition of the aircraft and are therefore subject to dynamic changes. These changes are made either automatically, based on inputs received from sensors in the aircraft, or manually by the flight crew.

a. Pressure Altitude

When operated in conjunction with a pressure-altitude encoder (digitizer) or an air data system, the transponder **shall** have the capability for pressure-altitude transmission up to its designed maximum altitude. Pressure altitude reports **shall** be referenced to a standard pressure setting of 29.92 inches Hg (1013.25 hectopascals).

(1) ATCRBS – When operated in the ATCRBS system, the altitude **shall** be transmitted in response to a Mode C interrogation, encoded in accordance with ICAO Annex 10. If valid altitude information is not available to the transponder, only the framing pulses required for a Mode C response **shall** be transmitted.

(2) Mode S – When operated in the Mode S system, the 13-bit AC field (bits 20 – 32 transmitted in the short and long special surveillance reply, the altitude surveillance reply, and the altitude Comm-B reply) **shall** contain the encoded altitude of the aircraft. For aircraft with 25-foot or better pressure altitude sources, pressure altitude-information should be reported in 25-foot increments. Pressure altitude data obtained from a source with larger than 25-foot resolution **shall not** be reported using 25-foot increments. The altitude **shall** be encoded as follows:

(i) Bit 26 **shall** be designated as the M bit and **shall** be ZERO if the altitude is reported in feet. M equals ONE **shall** be reserved for possible future use to indicate that the altitude reporting is in metric units.

Note: *Use of the M bit as defined here does not alter any conventions regarding the X bit in ATCRBS replies.*

(ii) If M equals ZERO, bit 28 **shall** be designated as the Q bit. Q equals ZERO **shall** be used to indicate that the Mode S altitude is reported in 100-foot increments as defined in c below. Q equals ONE **shall** be used to indicate that the altitude is reported in 25-foot increments as defined in d below.

Note: *Bit 28 (Q) corresponds to the D1 pulse of a Mode C reply and is not used in the ATCRBS altitude code.*

(iii) If M and Q both equal ZERO, the altitude **shall** be coded according to the pattern for Mode C replies specified in ICAO Annex 10. Starting with bit 20, the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, ZERO, B2, D2, B4, D4.

(iv) If M equals ZERO and Q equals ONE, the 11-bit field represented by bits 20 to 25, 27, and 29 to 32 **shall** represent a binary-coded field whose least significant bit has a value of 25 feet. The binary value of the decimal number N **shall** be used to report pressure altitudes in the range (25 x N – 1000 ±12.5) feet.

Note: *The most significant bit of this field is bit 20 as required by §2.2.14.4.2. This code is able to provide code values only between -1000 feet and +50175 feet. The coding used for Mode C replies in "c" above must be used to report pressure altitudes greater than 50175 feet.*

(v) ZERO **shall** be transmitted in each of the 13 bits of the AC field if altitude information is not available or if the altitude has been determined to be invalid.

b. 4096 Identification Code

In response to an ATCRBS Mode A or Mode S surveillance or Comm-A identity interrogation, the transponder **shall** reply with a pilot-selectable identification code. The code designation **shall** consist of digits between 0 and 7 inclusive, and **shall** consist of the sum of the postscripts of the information pulse numbers defined in §2.2.4.1.2, employed as follows:

Digit	**Pulse Group**
First	A
Second	B
Third	C
Fourth	D

Example:

Code 3615 would consist of information pulses A1, A2 (1 + 2 = 3), B2, B4 (2 + 4 = 6), C1 (1 = 1), D1, D4 (1 + 4 = 5).

In the ATCRBS mode, this code, together with the framing pulses and a possible SPI pulse, makes up the complete Mode A reply. In Mode S, the identification pulses become the "ID" field (see §2.2.14.4.17), bits 20 – 32.

c. “On-the-Ground” Condition

The transponder **shall** report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in §2.2.18.2.7.

Note: *The on-the-ground state determined by the aircraft does not include the effect of any TCS commands (see §2.2.23.1.7).*

d. Special Position Identification (SPI)

In the ATCRBS mode, an SPI pulse **shall** be transmitted upon request, following a Mode A reply. In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse **shall** be transmitted upon the same request. The code is transmitted for 18 ±1.0 seconds after initiation and can be reinitiated at any time.

e. Aircraft Identification Data

If the aircraft uses a flight number for aircraft identification, a means **shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground, or during flight. The means for modifying and displaying aircraft identification **shall** be a simple crew action independent of the entry of other flight data.

f. Radio Altitude Data

If available, the radio altitude data input is used to support airborne/on-the-ground determination in installations that support automatic on-the-ground condition determination as specified in §2.2.18.2.7. The data supports Extended Squitter airborne/surface format transmission selection and Flight Status (FS), Vertical Status (VS), and Capability (CA) fields as provided in §2.2.23.1.5, §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6.

g. Ground Speed Data

If available, the ground speed data input is used to support airborne/on-the-ground determination in installations that support automatic on-the-ground condition determination as specified in §2.2.18.2.7. The data supports Extended Squitter airborne/surface format transmission selection and Flight Status (FS), Vertical Status (VS), and Capability (CA) fields as provided in §2.2.23.1.5, §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6.

h. Airspeed Data

If available, the airspeed data input is used to support airborne/on-the-ground determination in installations that support automatic on-the-ground condition determination as specified in §2.2.18.2.7. The data supports Extended Squitter airborne/surface format transmission selection and Flight Status (FS), Vertical Status (VS), and Capability (CA) fields as provided in §2.2.23.1.5, §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6.

2.2.13.2 Indirect Data

Indirect data are those which pass through the transponder in either direction, but which do not affect the surveillance protocol. If the transponder is designed to function with data link devices outside the transponder equipment, the input and output interfaces should satisfy the following requirements. As used here, “transponder equipment” refers to a physical unit or group of units that would normally be installed as a system.

The manufacturer is free to design the interfaces with these internal data link devices as long as the requirements of the following paragraphs are met.

2.2.13.2.1 Interfaces for Indirect Data

Operational requirements of the Mode S installation influence the need for and the design of transponder interfaces for indirect data. If such interfaces are provided, those for standard Mode S transactions (see §2.2.13.3) may be separate from those for ELM service.

2.2.13.2.2 Integrity of Interface Data Transfer

If a data link interface is employed, the interface **shall** be designed to provide communication between the transponder and peripheral devices in the normal operational aircraft environment for that class of transponder to assure error rates of less than one detected error in 10^3 112-bit transmissions and less than one undetected error in 10^7 112-bit transmissions for both uplink and downlink transfers.

2.2.13.3 Standard Transaction Interfaces

Standard Mode S transactions involve the content of all Mode S interrogation and reply formats with the possible exception of the All-Call and the Comm-C/D and the Comm-U/V formats. Various implementations of interfaces for uplink and downlink messages may be employed. In general, the transponder passes data to the data link interface regardless of the content of the 56 bit data field. The Mode S Specific Protocol (MSP) channel header (see §C.2.2.6.2) must be read by a TCAS compatible transponder to determine if the MA field contains a Sensitivity Level Command to be directed to the TCAS interface (see §2.2.22.1.1). Other MSP channels may also be directed to individual interfaces (e.g., TIS MSP Channel 2, Data Flash, MSP Channel 3).

2.2.13.3.1 Uplink Interface

a. Information Content – The interface **shall** transfer the entire content of both short and long accepted uplink interrogations (with the possible exception of the AP Field) except for interrogations UF=0, 11, 16 and a UF=24 interrogation containing a request for a downlink ELM transfer (RC=3). This permits the receiving devices to properly identify the data field contents and permits possible additional parity determination at the I/O device.

b. No-Storage Design – If the interface design is based on the concept of shifting data out of the transponder as they are received, the interface **shall** be capable of transferring uplink content before the start of the corresponding reply.

c. Storage Design, Acceptance Rate – If the interface design is based on the concept of shifting data out at a slower rate, the internal storage system **shall** be able to process the content of Mode S interrogations (long or short) at a rate greater than or equal to:

50 long interrogations in any 1-second interval
18 long interrogations in any 100-millisecond interval
8 long interrogations in any 25-millisecond interval
4 long interrogations in any 1.6-millisecond interval.

Note: *Ability to receive higher interrogation rates is required by a TCAS-compatible transponder (see §2.2.22.b.).*

d. Storage Design, Non-Acceptance – The transponder may optionally accept a Comm-A interrogation (UF=20, 21) if the data content of that interrogation cannot be processed (see 'UNABLE TO PROCESS' and 'OPTION TO REPLY', Figure 2-15).

Note: *The Mode S reply is the sole means of acknowledging receipt of an interrogation. Therefore, there is benefit to interrogators to receive a reply, even if the airborne data system is not capable of accepting the data contained in the interrogation. Overlapping Mode S beams from several interrogators could lead to the requirement for considerable data handling and buffering. The minimum, prescribed in "c" above, reduces data handling to a realistic level.*

e. Broadcast Information – Regardless of design (No-Storage or Storage), the uplink interface **shall** have a means to indicate to the recipient that a received message was sent as a broadcast.

2.2.13.3.2 Downlink Interface

a. Information Content – The interface **shall** be able to insert into the downlink transmission any bit not inserted by the transponder.

b. No-Storage Design – If the interface is designed to insert bits into the transponder for immediate transmission, such bits **shall** occur at the interface at least one microsecond before actual transmission.

c. Storage Design – Buffer Rate – If the interface shifts data into the transponder at a rate slower than the transmission rate, the internal data system **shall** be able to provide the data to support the reply rate specified in §2.2.3.4.2.

Note: *Certain transponder designs may require downlink registers called for by an RR value, as well as downlink registers called for by special formats or DI content.*

d. Storage Design – Buffer Function – The design **shall** ensure that register content **shall not** be in a state of transition during the insertion of the content in a downlink reply.

e. Unavailable Data – If an interrogation requests, as in "c" above, data that are not available, the transponder **shall** insert ZERO (0) into the affected fields of the reply.

Note: *The no-storage design requirement can be met by assuring that a non-connected data source or an open interface connection results in zero-level inputs. The storage design requirement can be met by assuring the transmission of "0" if the readout from a nonexistent register is requested. An input to provide information for air-initiated multisite directed transmissions (see §2.2.19.2.3.2 and §2.2.20.2.3.2) may have to be provided.*

2.2.13.4 ELM Service Interfaces

ELM transactions involve the content of Mode S interrogation and reply formats UF=DF=24, Comm-C and Comm-D respectively. The reservation and closeout protocol uses the surveillance and Comm-A/B formats, UF=DF=4, 5, 20, 21.

Separate interfaces may be provided for the uplink and the downlink, or a single interface handling both directions may be employed.

2.2.14 Description of the Mode S Signal Format

Note: *Protocols relating to the use of formats and fields are described in §2.2.17 through §2.2.19.*

2.2.14.1 Format Structure, Interrogation and Reply

Formats **shall** contain either 56 or 112 bits, the last 24 of which are used for address and parity while the rest are used for information transfer. A summary of interrogation and reply formats is presented in Figure 2-5 and Figure 2-6.

Format #	UF								
0	0 0000	- 3 -	RL: 1	- 4 -	AQ: 1	DS: 8	- 10 -	AP: 24	. . . Short Air-Air Surveillance (ACAS)
1	0 0001	- 27 or 83 -						AP: 24	
2	0 0010	- 27 or 83 -						AP: 24	
3	0 0011	- 27 or 83 -						AP: 24	
4	0 0100	PC : 3	RR : 5	DI : 3	SD : 16			AP: 24	. . . Surveillance. Altitude Request
5	0 0101	PC : 3	RR : 5	DI : 3	SD : 16			AP : 24	. . . Surveillance, Identity Request
6	0 0110	- 27 or 83 -						AP : 24	
7	0 0111	- 27 or 83 -						AP : 24	
8	0 1000	- 27 or 83 -						AP : 24	
9	0 1001	- 27 or 83 -						AP : 24	
10	0 1010	- 27 or 83 -						AP : 24	
11	0 1011	PR : 4	IC : 4	CL : 3	- 16 -			AP : 24	. . . Mode S-Only All-Call
12	0 1100	- 27 or 83 -						AP : 24	
13	0 1101	- 27 or 83 -						AP : 24	
14	0 1110	- 27 or 83 -						AP : 24	
15	0 1111	- 27 or 83 -						AP : 24	
16	1 0000	- 3 -	RL: 1	- 4 -	AQ: 1	- 18 -	MU: 56	AP: 24	. . . Long Air-Air Surveillance (TCAS)
17	1 0001	- 27 or 83 -						AP: 24	
18	1 0010	- 27 or 83 -						AP: 24	
19	1 0011	Military Use : 107							. . . Military Use
20	1 0100	PC : 3	RR : 5	DI : 3	SD : 16	MA : 56		AP: 24	. . . Comm-A, Altitude Request
21	1 0101	PC : 3	RR : 5	DI : 3	SD : 16	MA : 56		AP: 24	. . . Comm-A, Identity Request
22	1 0110	- 27 or 83 -						AP: 24	. . . Reserved for Military Use
23	1 0111	- 27 or 83 -						AP: 24	
24	1 1	RC : 2	NC : 4	MC : 80				AP: 24	. . . Comm-C (ELM)

Figure 2-5: Overview of Mode-S Interrogation Formats

Notes:

1. *[XX:M] denotes a field designated "XX" which is assigned M bits.*
2. *[- N -] denotes free coding space with N available bits. These **shall** be coded as ZEROs for transmission.*
3. *For uplink formats (UF) 0 through 23 the format number corresponds to the binary code in the first 5 bits of the interrogation. Format number 24 is defined as the format beginning with "11" in the first two bit positions while the following three bits vary with the interrogation content.*
4. *All formats are shown for completeness, although a number of them are unused. Those formats for which no application is defined remain undefined in length. Depending on future assignments, they may be short (56-bit) or long (112-bit) formats. Specific formats associated with Mode S capability levels are defined in this document.*
5. *The PC, RR, DI and SD Fields do not apply to a Comm-A broadcast interrogation.*

Format #	DF		
0	0 0000	VS: 1 · CC: 1 · -1- · SL: 3 · -2- · RI: 4 · -2- · AC: 13 · AP: 24	. . . Short Air-Air Surveillance (ACAS)
1	0 0001	- 27 or 83 - · P: 24	
2	0 0010	- 27 or 83 - · P: 24	
3	0 0011	- 27 or 83 - · P: 24	
4	0 0100	FS : 3 · DR : 5 · UM : 6 · AC : 13 · AP: 24	. . . Surveillance. Altitude Reply
5	0 0101	FS : 3 · DR : 5 · UM : 6 · ID : 13 · AP : 24	. . . Surveillance, Identity Reply
6	0 0110	- 27 or 83 - · P : 24	
7	0 0111	- 27 or 83 - · P : 24	
8	0 1000	- 27 or 83 - · P : 24	
9	0 1001	- 27 or 83 - · P : 24	
10	0 1010	- 27 or 83 - · P : 24	
11	0 1011	CA : 3 · AA : 24 · PI : 24	. . . All-Call Reply
12	0 1100	- 27 or 83 - · P : 24	
13	0 1101	- 27 or 83 - · P : 24	
14	0 1110	- 27 or 83 - · P : 24	
15	0 1111	- 27 or 83 - · P : 24	
16	1 0000	VS: 1 · -2- · SL: 3 · -2- · RI: 4 · -2- · AC: 13 · MV: 56 · AP: 24	. . . Long Air-Air Surveillance (TCAS)
17	1 0001	CA : 3 · AA : 24 · ME : 56 · PI: 24	. . . Extended Squitter
18	1 0010	CF : 3 · AA : 24 · ME : 56 · PI: 24	. . . Extended Squitter / Non-Transponder
19	1 0011	AF: 3 · Military Application : 104	. . . Military Application
20	1 0100	FS: 3 · DR: 5 · UM: 6 · AC: 13 · MB: 56 · AP: 24	. . . Comm-B, Altitude Reply
21	1 0101	FS : 3 · DR : 5 · UM : 6 · ID : 13 · MB : 56 · AP: 24	. . . Comm-B, Identity Reply
22	1 0110	- 27 or 83 - · P: 24	. . . Reserved for Military Use
23	1 0111	- 27 or 83 - · P: 24	
24	1 1	- 1 - · KE : 1 · ND : 4 · MD : 80 · AP: 24	. . . Comm-D (ELM)

Figure 2-6: **Overview of Mode S Reply Formats**

Notes:

1. *[XX:M] denotes a field designated "XX" which is assigned M bits. [P:24] denotes a 24-bit field reserved for parity information.*
2. *[- N -] denotes free coding space with N available bits. These **shall** be coded as ZEROs for transmission.*
3. *For downlink formats (DF) 0 through 23 the format number corresponds to the binary code in the first 5 bits of the interrogation. Format number 24 is defined as the format beginning with "11" in the first two bit positions while the following three bits vary with the reply content.*
4. *All formats are shown for completeness, although a number of them are unused. Those formats for which no application is defined remain undefined in length. Depending on future assignments, they may be short (56-bit) or long (112-bit) formats. Specific formats associated with Mode S capability levels are defined in this document.*

2.2.14.2 Bit Numbering and Sequence

Bits are numbered in order of their transmission, beginning with bit 1. If numerical values are encoded by groups of bits (fields), then the first bit transmitted is the most significant bit (MSB) unless otherwise stated.

2.2.14.3 Fields

Information is coded in fields which consist of at least one bit. The decimal equivalent of the binary code formed by the bit sequence within a field is used as the designator of the field function.

2.2.14.3.1 Essential Fields

Each Mode S transmission contains two essential fields: One describing the format and the other a 24-bit field which carries parity information and contains either the address or the interrogator identity overlaid on parity as described in §2.2.18.2.1. The format descriptor is the field at the beginning of the transmission and the 24-bit field always occurs at the end of the transmission. The formats are described by the UF or DF descriptors.

2.2.14.3.2 Mission Fields

The remaining coding space is used to transmit the mission fields. For specific missions, a specific set of fields is prescribed. Mission fields have two-letter designators.

2.2.14.3.3 Subfields

Subfields may appear within mission fields. Subfields are labeled with three-letter designators.

2.2.14.4 Field Descriptions

Fields are described in alphabetical order in the following paragraphs and are indexed in Figure 2-7.

		BITS		FORMATS		REFERENCE PARAGRAPH (S)	
FIELD	SUB FIELD	NO.	POSITION	UP	DOWN	CONTENT	PROTOCOL
AA		24	9-32		X	§2.2.14.4.1	§2.2.18.2.10
AC		13	20-32		X	§2.2.14.4.2	§2.2.18.2.10
AF		3	6-8		X	§2.2.14.4.3	§2.2.23.3.1
AP		24 24	33-56 89-112	X	X	§2.2.14.4.4	§2.2.18.2.1, §2.2.18.2.2
AQ		1	14	X		§2.2.14.4.5	§2.2.18.2.6
CA		3	6-8		X	§2.2.14.4.6	§2.2.18.2.8
CC		1	7		X	§2.2.14.4.7	§2.2.14.4.7
CF		3	6-8		X	§2.2.14.4.8	See RTCA DO-260B EUROCAE ED-102A
CL		3	14 - 16	X		§2.2.14.4.9	§2.2.14.4.9
DF		5	1-5		X	§2.2.14.4.10	§2.2.18.2.3, §2.2.19.1.4
DF=24		2	1-2		X	§2.2.14.1	
DI		3	14 - 16	X		§2.2.14.4.11	§2.2.18.2.5, §2.2.19.2.1.1, §2.2.19.1.12
DP		24	89-112		X	§2.2.14.4.12	§2.2.19.1.12.1, §2.2.19.1.12.2
DR		5	9-13		X	§2.2.14.4.13	§2.2.20.2.1.1.1, §2.2.19.1.12.4
DS		8	15-22	X		§2.2.14.4.14	§2.2.19.1.18
FS		3	6-8		X	§2.2.14.4.15	§2.2.18.2.7
IC		4	10-13	X		§2.2.14.4.16	§2.2.14.4.16
ID		13	20-32		X	§2.2.14.4.17	§2.2.18.2.10
II [2]		4				§2.2.14.4.18	§2.2.18.2.2.g, §2.2.18.2.4 §2.2.18.2.5
KE		1	4		X	§2.2.14.4.19	§2.2.20.1.1.1.5, §2.2.20.2.1.1.2
MA		56	33-88	X		§2.2.14.4.20	§2.2.19.1.10
MB		56	33-88		X	§2.2.14.4.21	§2.2.19.1.12, §2.2.22.1.2.3
	AIS	48	41-88		X	§2.2.19.1.13	§2.2.19.1.13
	ARA	14	41-54		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	ATS	1	35		X	§2.2.23.1.9	§2.2.23.1.8
	BDS	8	33-40		X	§2.2.14.4.21	§2.2.19.1.12.1, §2.2.22.1.2.1, §2.2.22.1.2.2
	MTE	1	60		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	OCC	1	47		X	§2.2.19.1.12.6.2	§2.2.19.1.12.6.2
	RAC	4	55-58		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	RAT	1	59		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	SCS	1	34		X	§2.2.19.1.12.6.2	§2.2.19.1.12.6.2
	SIC	1	35		X	§2.2.19.1.12.6.2	§2.2.19.1.12.6.2
	TID	26	63-88		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	TIDA	13	63-75		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	TIDB	6	83-88		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	TIDR	7	76-82		X	§2.2.22.1.2.1	§2.2.22.1.2.1
	TRS	2	33-34		X	§2.2.23.1.9	§2.2.23.1.6
	TTI	2	61-62		X	§2.2.22.1.2.1	§2.2.22.1.2.1
MC		80	9-88	X		§2.2.14.4.22	§2.2.20.1.1.1
	IIS	4	9-12	X		§2.2.19.2.1.2	§2.2.19.2
	IIS	4	25-28			§2.2.19.2.1.2	§2.2.19.2
	SRS	16	9-24	X		§2.2.20.2.1.1.3	§2.2.20.2.1.1.2
MD		80	9-88		X	§2.2.14.4.23	§2.2.20.1.1.1, §2.2.20.2.1.1
	TAS	16	17-32		X	§2.2.20.1.1.1.6	§2.2.20.1.1.1.5
ME		56	33-88		X	§2.2.14.4.24	§2.2.14.4.24
	ACS	12	41-52		X	§2.2.23.1.8	§2.2.23.1.8

		BITS		FORMATS		REFERENCE PARAGRAPH (S)	
FIELD	**SUB FIELD**	**NO.**	**POSITION**	**UP**	**DOWN**	**CONTENT**	**PROTOCOL**
	SSS	2	38-39		X	§2.2.23.1.8	§2.2.23.1.8
MU		56	33-88	X		§2.2.14.4.25	§2.2.19.1.16
MV		56	33-88		X	§2.2.14.4.26	§2.2.19.1.16
	ARA	14	41-54		X	§2.2.22.1.4.2	§2.2.22.1.4.2
	MTE	1	60		X	§2.2.22.1.4.2	§2.2.22.1.4.2
	RAC	4	55-88		X	§2.2.22.1.4.2	§2.2.22.1.4.2
	RAT	1	59		X	§2.2.22.1.4.2	§2.2.22.1.4.2
NC		4	5-8	X		§2.2.14.4.27	§2.2.20.1.1.1
ND		4	5-8		X	§2.2.14.4.28	§2.2.20.2.1.1.2
PC		3	6-8	X		§2.2.14.4.29	§2.2.18.2.4, §2.2.19.1.12, §2.2.20.1.1.1, §2.2.20.2.1
PI		24	33-56		X	§2.2.14.4.30	§2.2.18.2.1
PR		4	6-9	X		§2.2.14.4.31	§2.2.18.2.2.i.
RC		2	3- 4	X		§2.2.14.4.32	§2.2.20.1.1.1, §2.2.20.2.1.1.3
RI		4	14-17		X	§2.2.14.4.33	§2.2.18.2.10
RL		1	9	X		§2.2.14.4.34	
RR		5	9-13	X		§2.2.14.4.35	§2.2.19.1.4, §2.2.19.1.12.2, §2.2.19.1.12.4, §2.2.19.1.13
SD		16	17-32	X		§2.2.14.4.36	§2.2.19.1.12.2, §2.2.19.2
	IIS	4	17-20	X		§2.2.14.4.36	§2.2.18.2.5, §2.2.19.2
	LOS	1	26	X		§2.2.19.2.1.1	§2.2.18.2.5
	LSS	1	23	X		§2.2.19.2.1.1	§2.2.18.2.5
	MBS	2	21-22	X		§2.2.19.2.1.1	§2.2.19.2.3.1
	MES	3	23-25	X		§2.2.19.2.1.1	§2.2.20.1.3.1, §2.2.20.2.3.1
	OVC	1	28	X		§2.2.19.2.1.1.h	§2.2.19.1.12.1, §2.2.19.1.12.2
	RCS	3	24-26	X		§2.2.23.1.7	§2.2.23.1.6
	RRS	4	21-24	X		§2.2.19.1.12.2	§2.2.19.2.1.1.(d)
	RRS	4	24-27	X		§2.2.19.1.12.2	§2.2.19.2.1.1.(f)
	RSS	2	27-28	X		§2.2.19.2.1.1	§2.2.19.2
	SAS	2	27-28	X		§2.2.23.1.7	§2.2.12.5.1
	SIS	6	17-22	X		§2.2.19.2.1.1	§2.2.18.2.5
	TCS	3	21-23	X		§2.2.23.1.7	§2.2.23.1.5
	TMS	4	29-32	X		§2.2.19.2.1.1	
SI [2]		6		X	X	§2.2.14.4.37	§2.2.18.2.5, §2.2.18.2.9
SL		3	9-11		X	§2.2.14.4.38	§2.2.22.3.1
UF		5	1-5	X		§2.2.14.4.40	
UF=24		2	1-2	X		§2.2.14.1	
UM		6	14-19		X	§2.2.14.4.40	
	IDS	2	18-19		X	§2.2.19.2.1.2	
	IIS	4	14-17		X	§2.2.19.2.1.2	
VS		1	6		X	§2.2.14.4.42	§2.2.18.2.10

<u>Figure 2-7:</u> Field Index

<u>Notes:</u>

1. *The PC, RR, DI and SD Fields do not apply to a Comm-A broadcast interrogation.*
2. *The II and SI Fields are not actual fields, but are included in the table for reference.*

2.2.14.4.1 AA Address, Announced

This 24-bit (bits 9 – 32) downlink field contains the aircraft address in the clear and is used in DF=11, the All-Call reply.

2.2.14.4.2 AC Altitude Code

This 13-bit (bits 20 – 32) downlink field contains the altitude code (see §2.2.13.1.2.a.) and is used in formats DF=0, 4, 16, and 20. ZERO is transmitted in each of the 13 bits if altitude information is not available. Metric altitude is contained in this field if the M-bit (bit 26) is ONE.

2.2.14.4.3 AF Application Field

This 3-bit (bits 6 – 8) downlink field in DF=19 **shall** be used to define the format of the 112-bit transmission.

Code 0	=	ADS-B Format
Code 1	=	Military TCAS – Formation Flight System
Code 2 to 7	=	Reserved

2.2.14.4.4 AP Address/Parity

This 24-bit field (bits 33 – 56, or bits 89 – 112) contains parity overlaid on the address according to §2.2.18.2.1 and appears at the end of all uplink and currently defined downlink formats with the exception of format DF=11.

2.2.14.4.5 AQ Acquisition Special

This 1-bit field (bit 14) designates formats UF=0, 16 as acquisition transmissions and is repeated as received by the transponder in DF=0, 16 (see Note in §2.2.14.4.33).

2.2.14.4.6 CA Transponder Capability

This 3-bit (bits 6 – 8) downlink field is used in DF=11, the All-Call reply and acquisition squitter, and in DF=17, the Extended Squitter. The codes are:

Code	Description
0	signifies Level 1 transponder (surveillance only), and no ability to set CA code 7, and either on the ground or airborne
1	Reserved
2	Reserved
3	Reserved
4	signifies Level 2 or above transponder, and ability to set CA code 7, and on the ground
5	signifies Level 2 or above transponder, and ability to set CA code 7, and airborne
6	signifies Level 2 or above transponder, and ability to set CA code 7, and either on the ground or airborne
7	signifies DR is NOT equal to ZERO, or FS equals 2, 3, 4 or 5, and either on the ground or airborne (see §2.2.14.4.13 and §2.2.14.4.15)

When the conditions for CA code 7 are not satisfied, Level 2 or above transponders in installations that do not have automatic means to set on-the-ground conditions **shall** use CA code 6. Aircraft with automatic on-the-ground determination **shall** use CA codes 4 when on-the-ground, and 5 when airborne. Data link capability reports (see §2.2.19.1.12.6) **shall** be available from aircraft installations that set CA codes 4, 5, 6 or 7.

Note: *CA codes 1 to 3 are reserved to maintain backward compatibility.*

2.2.14.4.7 CC: Crosslink Capability

This 1-bit (bit 7) downlink field **shall** indicate the ability of the transponder to support the crosslink capability, i.e., decode the contents of the DS field in a UF=0 interrogation and respond with the contents of the specified ground-initiated Comm-B register in the MV field of the corresponding DF=16 reply. It is used in format DF=0. The codes are:

0 = aircraft cannot support the crosslink capability
1 = aircraft supports the crosslink capability.

2.2.14.4.8 CF Control Field

This 3-bit (bits 6 – 8) downlink field in DF=18 **shall** be used to define the format of the 112-bit transmission.

Code 0	=	ADS-B format
Code 1 to 7	=	Reserved

2.2.14.4.9 CL Code Label

This 3-bit (bits 14 – 16) uplink field **shall** define the contents of the IC field. Coding (in binary):

Code	Description
000	IC Field contains the II code
001	IC Field contains SI codes 1 to 15
010	IC Field contains SI codes 16 to 31
011	IC Field contains SI codes 32 to 47
100	IC Field contains SI codes 48 to 63

The other values of the CL field **shall not** be used.

Note: *The II code is defined in §2.2.14.4.18 and the SI code is defined in §2.2.14.4.37.*

2.2.14.4.10 DF Downlink Format

The first field in all downlink formats is the transmission descriptor and is coded according to Figure 2-6, Note (3).

2.2.14.4.11 DI Designator Identification

This three-bit (bits 14 – 16) uplink field identifies the coding contained in the SD field in formats UF=4, 5, 20 and 21. The codes are:

Code	Description
0	SD contains IIS (see §2.2.19.2.1.1), bits 21-27 and 29-32 are not assigned, and bit 28 contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h)
1	SD contains multisite II lockout and multisite data link protocol information (see §2.2.19.2.1.1)
2	SD contains Extended Squitter control information (see §2.2.23.1.6)
3	SD contains multisite SI lockout information (see §2.2.19.2.1.1) and extended data readout (see §2.2.19.1.12.2), and bit 28 contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h)
4	Signifies SD not assigned
5	Signifies SD not assigned
6	Signifies SD not assigned
7	SD contains extended data readout request (see §2.2.19.1.12.2), and bit 28 contains the "OVC" (Overlay Command) (see §2.2.19.2.1.1.h)

2.2.14.4.12 DP Data Parity

This 24 bit (bits 89 – 112) downlink field contains the parity overlaid on a "Modified AA" field established by performing a modulo-2 summation (e.g., Exclusive-Or function) of the discrete address most significant 8 bits and BDS1, BDS2, where BDS1 and BDS2 are provided by the "RR" and "RRS" as specified in §2.2.19.1.12.1 and §2.2.19.1.12.2.

Example:									
Discrete Address	=	AA AA AA Hex	=	1010	1010	1010	1010	1010	1010
BDS1, BDS2	=	5F 00 00 Hex	=	0101	1111	0000	0000	0000	0000
Discrete Address	⊕	BDS1, BDS2 Hex	=	1111	0101	1010	1010	1010	1010
"Modified AA"	=	F5 AA AA Hex	=	1111	0101	1010	1010	1010	1010

where "⊕" prescribes modulo-2 addition

The resulting "Modified AA" field then represents the 24 bit sequence (a1,a2…a24) that **shall** be used to generate the DP field in accordance with §2.2.18.2.1.c.

Notes:

1. *Effectively, the most significant 8 bits of the discrete Address (e.g., "AA" field) are first modulo-2 summed with the Register number of the Register being provided in the reply. The result of that process is then used to generate the DP field.*

2. *When the interrogator receives the reply, the parity decoder will decode the received "DP" into an equivalent modified "AA." The interrogator can then modulo-2 sum the most significant 8 bits of this modified "AA" with the intended register BDS1, BDS2 with the result being the original "AA" used in the interrogation that requested the reply.*

2.2.14.4.13 DR Downlink Request

This 5-bit (bits 9 – 13) downlink field is used to request extraction of downlink messages from the transponder by the interrogator and appears in formats DF=4, 5, 20 and 21. The codes are:

Code	Description
0	No downlink request
1	Request to send air-initiated Comm-B message (B bit set) (see §2.2.19.1.12.4)
2	TCAS information available
3	TCAS information available and request to send Comm-B message
4	Comm-B broadcast #1 available
5	Comm-B broadcast #2 available
6	TCAS information and Comm-B broadcast #1 available
7	TCAS information and Comm-B broadcast #2 available
8 – 15	Reserved
16 – 31	See Comm-D protocol, (see §2.2.20.2.1.1)

Codes 1-15 **shall** take precedence over codes 16-31 to permit the announcement of a Comm-B message to interrupt the announcement of a downklink ELM. This gives priority to the announcement of the shorter message. Announcement of the downlink ELM **shall** resume when the Comm-B is cleared.

2.2.14.4.14 DS: Comm-B Data Selector

This 8-bit (bits 15 – 22) uplink field **shall** contain the identity of the ground-initiated Comm-B register whose contents are to appear in the MV field of the corresponding reply. It is used in format UF=0.

Note: *The DS field is not included in UF=16 in order to eliminate any possible protocol interaction with the TCAS coordination function.*

2.2.14.4.15 FS Flight Status

This 3-bit (bits 6 – 8) downlink field reports the flight status of the aircraft and is used in formats DF=4, 5, 20 and 21. Aircraft without the means of automatically determining the on-the-ground condition **shall** always report airborne state. The codes are:

Code	Alert	SPI	Airborne	On the Ground
0	no	no	yes	no
1	no	no	no	yes
2	yes	no	yes	no
3	yes	no	no	yes
4	yes	yes	Either	
5	no	yes	Either	
6 is reserved and 7 is not assigned				

2.2.14.4.16 IC Interrogator Code

This 4-bit (bits 10 – 13) uplink field **shall** contain either the 4-bit II code (§2.2.14.4.18) or the lower 4 bits of the 6-bit SI code (§2.2.14.4.37) depending on the value of the CL field (§2.2.14.4.9).

2.2.14.4.17 ID Identification (4096 code)

This 13-bit (bits 20 – 32) downlink field in DF=5, 21 contains the 4096 identification code reporting the numbers as set by the pilot (see §2.2.13.1.2.b). Starting with bit 20, the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4 (see Annex 10, Volume IV, §3.1.2.6.7.1).

2.2.14.4.18 II Interrogator Identification

This 4-bit value **shall** define an interrogator identifier (II) code. These II codes **shall** be assigned to interrogators in the range of 0 to 15. An II code value of ZERO **shall not** be used by interrogators which use the multisite lockout protocols (see §2.2.18.2.5) or multisite communications protocols (see §2.2.19.2).

Note: *The same information also may appear in the IIS subfields (see §2.2.19.2.1.1 and §2.2.19.2.1.2).*

2.2.14.4.19 KE Control, ELM

This 1-bit (bit 4) downlink field defines the content of the ND and MD fields in Comm-D replies, DF=24. For coding see §2.2.20.1.1.1.5 and §2.2.20.2.1.1.2.

2.2.14.4.20 MA Message, Comm-A

This 56-bit (bits 33 – 88) uplink field contains messages directed to the aircraft and is part of Comm-A interrogations, UF=20, 21.

2.2.14.4.21 MB Message, Comm-B and BDS B-Definition Subfield

a. MB Message, Comm-B

This 56-bit (bits 33 – 88) downlink field contains messages to be transmitted to the interrogator and is part of the Comm-B replies DF=20, 21. In those formats that are transmitted using the ground-initiated Comm-B protocol of §2.2.19.1.12.3, the MB field contains the 8-bit Comm-B definition Subfield BDS.

b. BDS B-Definition Subfield

When included in MB, this 8-bit (bits 33 – 40) downlink subfield defines the content of the MB message field of which it is part. BDS is expressed in two groups of 4 bits each, BDS1 (bits 33 – 36) and BDS2 (bits 37 – 40).

Note: *The BDS subfield is only used in the MB field of a GICB message that may also be delivered via the broadcast Comm-B protocol. In this case the BDS field is needed to identify the contents of the message data. The BDS field is not used for GICB messages that are never sent via the broadcast protocol.*

2.2.14.4.22 MC Message, Comm-C

This 80-bit (bits 9 – 88) uplink field **shall** contain:

a. One of the segments of a sequence used to transmit an uplink ELM to the transponder containing the 4-bit (bits 9 – 12) IIS subfield; or

b. Control fields for requesting one or more downlink ELM segments; the 16-bit (bits 9 – 24) SRS subfield (§2.2.20.2.1.1.3) and the 4-bit (bits 25 – 28) IIS subfield.

The MC field is contained in UF=24.

2.2.14.4.23 MD Message, Comm-D

This 80-bit (bits 9 – 88) downlink field contains one segment of a sequence of segments transmitted by the transponder in the ELM mode. It may also contain a summary of received MC segments of an uplink ELM. MD is part of DF=24.

2.2.14.4.24 ME Message, Extended Squitter

This 56-bit (bits 33 – 88) downlink field is used to broadcast messages. It is used in format DF=17.

2.2.14.4.25 MU Message, Comm-U

This 56-bit (bits 33 – 88) uplink field contains information used in air-to-air exchanges and is part of the long special surveillance interrogation UF=16. This message field does not use the Comm-A protocol.

2.2.14.4.26 MV Message, Comm-V

This 56-bit (bits 33 – 88) downlink field contains information used in air-to-air exchanges and is part of the long special surveillance reply DF=16. This message field does not follow the Comm-B protocol.

2.2.14.4.27 NC Number of C-Segment

This 4-bit (bits 5 – 8) uplink field gives the number of a segment transmitted in an uplink ELM and is part of a Comm-C interrogation, UF=24. The protocol is described in §2.2.20.1.1.1.

2.2.14.4.28 ND Number of D-Segment

This 4-bit, (bits 5 – 8) downlink field gives the number of a segment transmitted in a downlink ELM and is part of a Comm-D reply, DF=24. The protocol is described in §2.2.20.2.1.1.

2.2.14.4.29 PC Protocol

This 3-bit (bits 6 – 8) uplink field contains operating commands to the transponder and is part of surveillance and Comm-A interrogations UF=4, 5, 20, 21. The codes are:

Code	Description
0	No changes in transponder state
1	Non-selective All-Call lockout
2	Reserved
3	Reserved
4	Close out B (see §2.2.19.1.12)
5	Close out C (see §2.2.20.1.1.1.7)
6	Close out D (see §2.2.20.2.1.1.4)
7	Reserved

The PC field values 2 through 7 **shall** be ignored and the values 0 and 1 **shall** be processed for surveillance or Comm-A interrogations containing DI=3 (see §2.2.19.2.1.1).

2.2.14.4.30 PI Parity/Interrogator Identity

This 24-bit (bits 33 – 56) downlink field contains the parity overlaid on the interrogator's identity code according to §2.2.18.2.1. PI is part of the Mode S All Call Reply and acquisition squitter (DF=11), and the Mode S Extended Squitter (DF=17).

The code used in downlink PI field generation **shall** be formed by a sequence of 24 bits (a_1, a_2, . . . a_{24}) where the first 17 bits are ZEROs, the next three bits are a replica of the code label (CL) field (see §2.2.14.4.9) and the last four bits are a replica of the interrogator code (IC) field (§2.2.14.4.16).

If the reply is made in response to a Mode A/C/S All-Call, a Mode S-only All-Call with CL field and IC field equal to ZERO, or is an acquisition or Extended Squitter, the II (see §2.2.14.4.18) and the SI (see §2.2.14.4.37) codes **shall** be set to ZERO.

2.2.14.4.31 PR Probability of Reply

This 4-bit (bits 6 – 9) uplink field contains commands to the transponder which specify the reply probability to the Mode S-Only All-Call interrogation UF=11 that contains the PR. A command to disregard any lockout state can also be given. The assigned codes are as follows:

Code	Description
0	Reply with probability = 1.
1	Reply with probability = ½.
2	Reply with probability = ¼.
3	Reply with probability = 1/8.
4	Reply with probability = 1/16.
5, 6, 7	Do not reply.
8	Disregard lockout, reply with probability = l.
9	Disregard lockout, reply with probability = ½.
10	Disregard lockout, reply with probability = ¼.
11	Disregard lockout, reply with probability = 1/8.
12	Disregard lockout, reply with probability = l/16.
13, 14, 15	Do not reply.

Note: *On receipt of a Mode S-Only All-Call containing a PR code other than 0 or 8, the transponder executes a random process and makes a reply decision for this interrogation in accordance with the commanded probability. Random occurrence of replies enables the interrogator to acquire closely spaced aircraft whose replies would otherwise synchronously garble each other.*

2.2.14.4.32 RC Reply Control

This 2-bit (bits 3 – 4) uplink field designates the transmitted segment as initial, intermediate or final if coded 0, l, 2 respectively. RC=3 is used to request Comm-D downlink action by the transponder. RC is part of the Comm-C interrogation, UF=24. The protocols are described in §2.2.20.1.1.1 and §2.2.20.2.1.1.2.

2.2.14.4.33 RI Reply Information, Air-To-Air

This 4-bit (bits 14 – 17) downlink field appears in the special surveillance replies DF=0, 16 and reports airspeed capability and type of reply to the interrogating aircraft. The coding is as follows:

Code	Description
0 – 7	Codes indicate that this is the reply to an air-to-air non-acquisition interrogation.
8 – 15	Codes indicate that this is an acquisition reply.
0	Non on-board TCAS
1	Reserved
2	On-board TCAS with resolution capability inhibited
3	On-board TCAS with vertical-only resolution capability
4	On-board TCAS with vertical and horizontal resolution capability
5 – 7	Reserved
8	No maximum airspeed data available.
9	Airspeed is less than or equal to 75 knots.
10	Airspeed is greater than 75 and less than or equal to 150 knots.
11	Airspeed is greater than 150 and less than or equal to 300 knots.
12	Airspeed is greater than 300 and less than or equal to 600 knots.
13	Airspeed is greater than 600 and less than or equal to 1200 knots.
14	Airspeed is greater than 1200 knots.
15	Reserved

Note: *Bit 14 of this field replicates the AQ bit (see §2.2.14.4.5) of the interrogation resulting in the coding scheme above.*

2.2.14.4.34 RL Reply Length

This 1-bit (bit 9) uplink field in UF=0, 16 commands a reply of DF=0 if ZERO, and a reply of DF=16 if ONE.

2.2.14.4.35 RR Reply Request

This 5-bit (bits 9 – 13) uplink field contains length and content of the reply requested by the interrogators. RR is part of the surveillance and Comm-A interrogations UF=4, 5, 20, 21. The codes are outlined below:

RR Code	Reply Length	MB Content
0-15	Short	-------
16	Long	Air-Initiated Comm B (§2.2.19.1.12.4)
17	Long	Data Link Capability Report (§2.2.19.1.12.6)
18	Long	Flight ID (§2.2.19.1.13)
19	Long	TCAS Resolution Advisory Report (§2.2.22.3.4)
20	Long	Selected Vertical Intention (Table B-3-64)
21	Long	Track and Turn Report (Table B-3-80)
22	Long	Heading and Speed Report (Table B-3-96)
23 – 31	Long	Reserved

Note: *If the first bit of the RR Code is ONE, the last four bits of the 5-bit RR Code, if transformed into their hexadecimal equivalent, designate the number (BDS1) of the requested source. BDS2 is assumed to be ZERO if not specified by DI=3 or 7 and RRS, as is consistent with §2.2.19.1.12.1. The data can also be extracted using the protocol of §2.2.19.1.12.2.*

2.2.14.4.36 Special Designator (SD), and IIS Subfield in SD

a. SD Special Designator

This 16-bit (bits 17 – 32) uplink field can contain control codes affecting transponder protocol and is part of surveillance and Comm-A interrogations UF=4, 5, 20, 21. The content of this field is specified by the DI field. See §2.2.19.2.1.1 for definitions of subfields in SD.

b. IIS, Subfield in SD

This 4-bit subfield (bits 17 – 20) appears in all SD fields of uplink formats 4, 5, 20 and 21 if the DI code is 0, 1 or 7. IIS is the Interrogator Identifier.

2.2.14.4.37 SI Surveillance Identifier

This 6-bit value **shall** define a surveillance identifier (SI) code which is derived from the CL and IC fields of UF=11, or received directly in the SIS subfield (see §2.2.19.2.1.1). These SI code values are assigned to interrogators in the range of 1 to 63. An SI value of ZERO will not be used. The SI codes are used with the multisite lockout protocols (see §2.2.18.2.5). The SI codes are not be used with the multisite communications protocols, which require the use of II codes. Therefore, an interrogator operating with an SI code will be limited to the following data link capabilities:

a. Unlinked Comm-A
b. Broadcast Comm-A
c. Ground-Initiated Comm-B (GICB)
d. Broadcast Comm-B
e. TCAS/ACAS Downlink Transactions

Notes:

1. *The SI lockout facility can not be used unless all Mode S transponders within coverage range are equipped for this purpose.*
2. *This specifically excludes the use of air-initiated Comm-B (AICB) protocol, which is required for data flash and downlink MSPs.*

2.2.14.4.38 SL TCAS Sensitivity Level Report

This 3-bit (bits 9 – 11) field appears in special surveillance reply formats DF=0, 16 (for TCAS-compatible transponders only). This field reports the sensitivity level at which the TCAS unit is currently operating.

The codes are:

Code	Description
0	No TCAS sensitivity level reported.
1	TCAS is operating at sensitivity level 1.
2	TCAS is operating at sensitivity level 2.
3	TCAS is operating at sensitivity level 3.
4	TCAS is operating at sensitivity level 4.
5	TCAS is operating at sensitivity level 5.
6	TCAS is operating at sensitivity level 6.
7	TCAS is operating at sensitivity level 7.

2.2.14.4.39 TMS Subfield

The Tactical Message Subfield (TMS), is a 4-bit subfield in SD (bits 29 – 32). This subfield is used for identifying linkage of Comm-A messages, with “0” indicating an unlinked message. Coding for this field is not described in these MOPS.

2.2.14.4.40 UF Uplink Format

The first field in all uplink formats is the transmission descriptor in all interrogations and is coded according to Figure 2-5, Note (3).

2.2.14.4.41 UM Utility Message in DF=4, 5, 20, 21

This 6-bit (bits 14 – 19) downlink field in DF=4, 5, 20, 21 contains transponder status readouts.

2.2.14.4.42 VS Vertical Status

This 1-bit (bit 6) downlink field in DF=0, 16 indicates, when ZERO, that the aircraft is airborne and, when ONE, that the aircraft is on the ground. Aircraft without the means of automatically determining the on-the-ground condition **shall** always report airborne state.

2.2.14.4.43 Free and Unassigned Coding Space

Free coding space as indicated in Figure 2-5 and Figure 2-6 contains ALL ZEROs as transmitted by interrogators and transponders. Non-assigned coding space within existing fields is reserved for possible future use.

2.2.14.4.44 Future Coding

Because yet unassigned free coding space is transmitted as ZEROs, future coding must define a ZERO's block as a default code, i.e., no message is sent, no command given, no capability exists if a future new field contains ALL ZEROs.

2.2.15 Antenna

2.2.15.1 Frequency Requirements

The antenna **shall** be designed to receive and transmit vertically polarized signals in the frequency range of 1030 to 1090 MHz.

2.2.15.2 Impedance and VSWR

The VSWR produced by the antenna when terminated in a 50 ohm transmission line **shall not** exceed 1.5:1 over the 1030 to 1090 MHz frequency band.

2.2.15.3 Polarization

The antenna **shall** be vertically polarized.

2.2.15.4 Radiation Pattern

The gain **shall not** be less than the gain of a matched quarter-wave stub minus 3 dB over 90 percent of a coverage volume from 0 to 360 degrees in azimuth and from 5 to 30 degrees above the ground plane when installed at the center of 1.2 meter (4 feet) diameter (or larger) flat circular ground plane.

2.2.16 Power Interruption

The transponder **shall** regain full operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Note: *The transponder is not required to continue operating during momentary power interruptions.*

2.2.17 Mode S Transponders

The Mode S transponder supports ground-to-air and air-to-air surveillance.

§1.4.3 of these MOPS indicates capabilities that become available through the use of Mode S and its data link. The paragraphs which follow provide a more detailed description of these various capabilities as they relate to the specific features which must exist within Mode S avionics. Each capability requires that the unit properly handle the associated formats, message fields, protocols and interfaces as specified in the referenced paragraphs.

2.2.18 Level 1 Mode S Transponder

This transponder supports the ground-based surveillance functions of both ATCRBS and Mode S and also air-to-air surveillance. It **shall** generate replies to valid ATCRBS Mode A and C interrogations. The Mode S formats to be processed and protocol requirements for this transponder are defined in the following paragraphs.

2.2.18.1 Mode S Formats

The transponder processes the 56-bit interrogations and 56-bit reply formats, listed in Figure 2-8 and Figure 2-9. See §2.2.14.4 for definition and coding of the applicable fields.

Format #	UF							
0	0 0000	- 3 -	RL : 1	- 4 -	AQ : 1	- 18 -	AP: 24	. . . Short Special Surveillance
4	0 0100	PC : 3	RR : 5	DI : 3	SD : 16		AP: 24	. . . Surveillance, Altitude Request
5	0 0101	PC : 3	RR : 5	DI : 3	SD : 16		AP: 24	. . . Surveillance, Identity Request
11	0 1011	PR: 4	IC: 4	CL: 3	- 16 -		AP: 24	. . . Mode S-Only All-Call

Figure 2-8: Level 1 Transponder: Uplink Formats

Format #	DF							
0	0 0000	VS : 1	- 7 -	RI : 4	- 2 -	AC : 13	AP: 24	. . . Short Special Surveillance
4	0 0100	FS : 3	DR : 5	UM : 6	AC : 13		AP: 24	. . . Surveillance, Altitude Reply
5	0 0101	FS : 3	DR : 5	UM : 6	ID : 13		AP: 24	. . . Surveillance, Identity Reply
11	0 1011	CA: 3	AA: 24				AP: 24	. . . All-Call Reply

Figure 2-9: Level 1 Transponder: Downlink Formats

2.2.18.2 Mode S Protocols

2.2.18.2.1 Error Protection (Figure 2-10 and Figure 2-11)

Parity check coding is used in Mode S interrogations and replies to provide protection against errors. The Mode S parity check code is defined in paragraphs "a," "b" and "c" below.

On receipt of a Mode S interrogation, the Mode S transponder **shall** perform a parity check, which is an examination of the sequence of demodulated bits to determine whether it is consistent with the code structure. If the bit sequence is consistent, the parity check is passed; otherwise it is failed. In this event the interrogation **shall not** be accepted.

Similarly, the Mode S transponder **shall** encode prior to transmitting a reply or squitter so that these transmissions are consistent with the code structure.

a. Parity Check Sequence – A sequence of 24 parity check bits, generated by a code described in “b,” is incorporated into the field formed by the last 24 bits of a11 Mode S transmissions. The 24 parity check bits are combined with either the address or the interrogator identification as described in “c.” The resulting combination then forms either the AP (Address/Parity) or the PI (Parity/Identification) field.

b. Parity Check Sequence Generation – The sequence of 24 parity bits (P_1, P_2, . . . P_{24}) is generated from the sequence of information bits (m_1, m_2, . . . m_k) where k is 32 or 88 for short or long transmissions respectively. This is done by means of a code generated by the polynomial:

$$G(x) = \sum_{i=0}^{24} g_i x^i$$

where g_i = 1 for I = 0, 3, 10 and 12 through 24.
0 otherwise

When by the application of binary polynomial algebra the above G(x) is divided into $[M(x)]x^{24}$ where the information sequence M(x) is expressed as:

$$M(x) = m_k + m_{k-1}x + m_{k-2}x^2 + \dots + m_1 x^{k-1}$$

the result is a quotient and a remainder R(x) of degree <24. The bit sequence formed by this remainder **shall** be the parity check sequence. Parity bit p_i for any “i” from 1 to 24, is the coefficient of x^{24-I} in R(x).

Note: *The effect of multiplying M(x) by x^{24} is to append 24 ZERO bits to the end of the sequence.*

c. AP or PI Field Generation – The address used for AP field generation is either the discrete address (§2.2.18.2.2.a) or the All-Call address (§2.2.18.2.2.b). The address **shall** be a sequence of 24 bits, (a_1, a_2 . . . a_{24}). In the discrete address, a_1 **shall** be the bit transmitted first in the AA field of an All-Call reply. This address sequence **shall** be used in the downlink Address/Parity field generation, while a modified form of this sequence (b_1, b_2 . . . b_{24}) **shall** be used for uplink Address/Parity field generation.

The interrogator identifier used for PI field generation is formed by a sequence of 24 bits, (a_1, a_2, . . . a_{24}) where the first 17 bits have ZERO value and the last seven bits are a replica of the CL and CI fields (see §2.2.14.4.30).

Bit b_i is the coefficient of x^{48-I} in the polynomial G(x)A(x), where:

$$A(x) = a_1x^{23} + a_2x^{22} + \ldots + a_{24}$$

and

G(x) is defined in §2.2.18.2.1 b.

The sequence of bits transmitted in the AP or PI field is:

$$t_{k+1}, t_{k+2} \ldots t_{k+24}$$

The bits are numbered in order of transmission, starting with k+1.

In interrogations:

$$t_{k+I} = b_i \oplus P_i$$

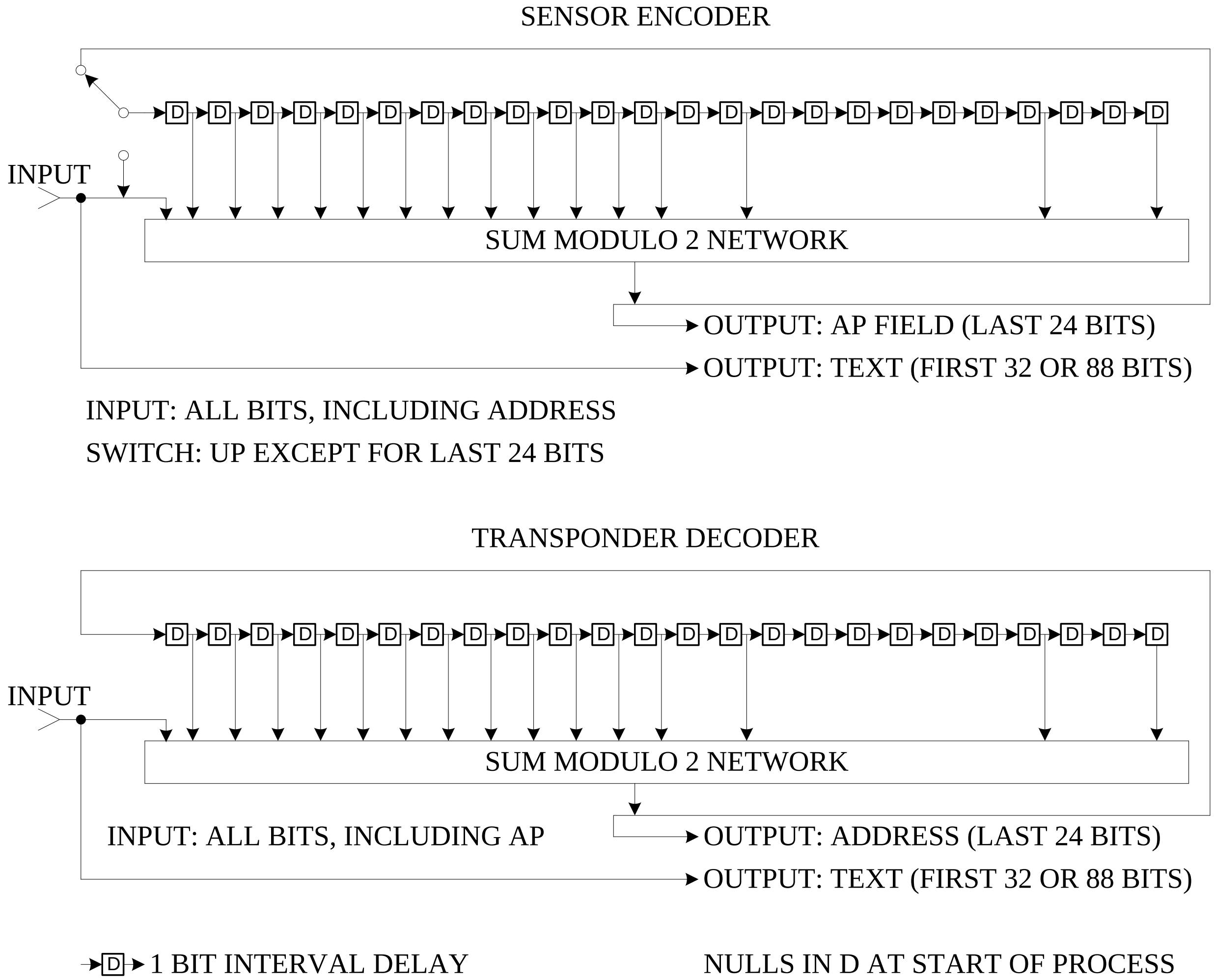
where "$\oplus$" prescribes modulo-2 addition; I = 1 is the first bit transmitted in the AP field.

In replies and squitters:

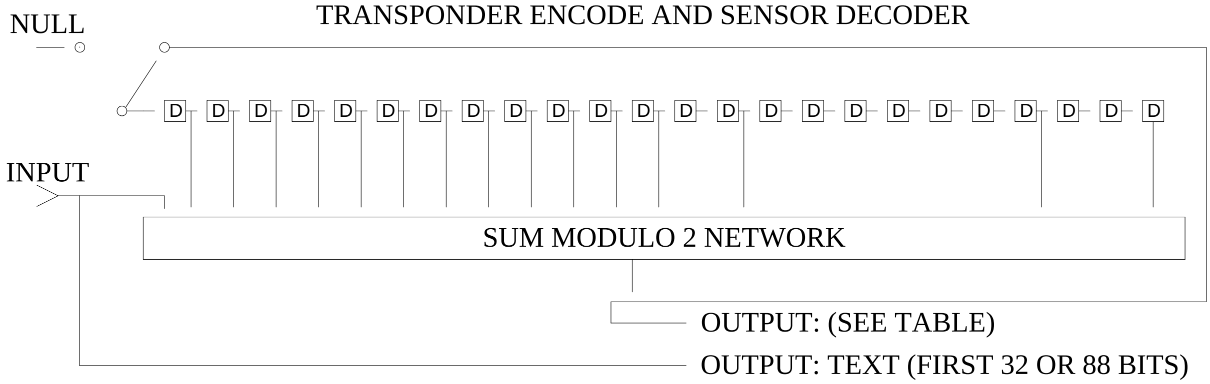
$$t_{k+I} = a_i \oplus P_i$$

where "$\oplus$" prescribes modulo-2 addition; I = 1 is the first bit transmitted in AP or PI field.

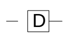
Note: *Figure 2-10 and Figure 2-11 show typical implementations of the error protection circuits and a sample of bit patterns.*



<u>Figure 2-10:</u> Functional Diagram of Uplink Coding



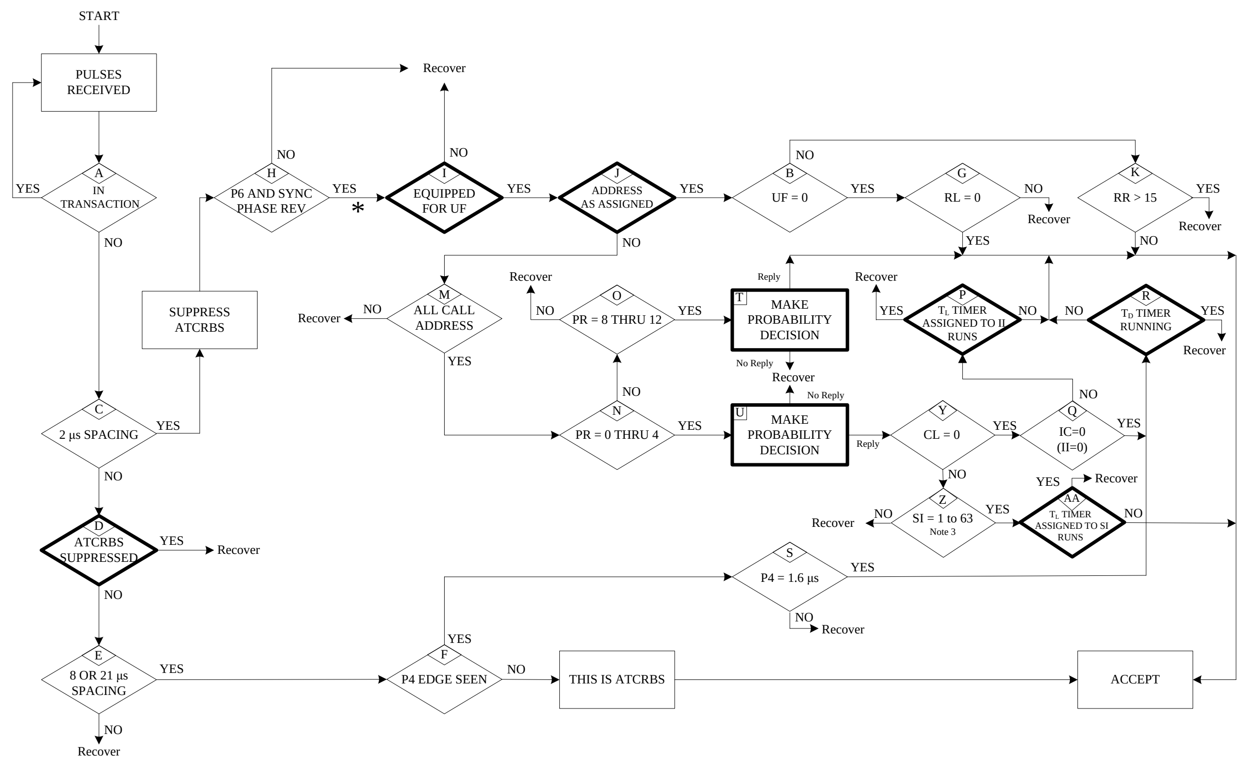
	TRANSPONDER	SENSOR
INPUT	ALL BITS, INCLUDING ADDRESS	ALL BITS INCLUDING AP FIELD
OUTPUT	AP FIELD = LAST 24 BITS	ADDRESS = LAST 24 BITS
SWITCH	RIGHT EXCEPT FOR LAST 24 BITS	



1 BIT INTERVAL DELAY NULLS IN D AT START OF PROCESS

<u>Figure 2-11:</u> Functional Diagram of Downlink Coding

2.2.18.2.2 Interrogation Acceptance Protocol (Figure 2-12)



<u>Figure 2-12:</u> The Level 1 Transponder: Interrogation Acceptance

<u>Notes:</u>

1. *Bold boxes indicate Transponder States.*
2. ** = Start of Mode S transaction cycle.*
3. *For SI=1, CL=1 and IC=1. For SI=63, CL=4 and IC=15.*

<u>Table 2-1:</u> Timer Characteristics

Timer Name	Number of Timers	Symbol	Duration (sec)	Tolerance (sec)	Can be Cancelled
Non-selective lock-out	1	T_D	18	±1	No
Temporary alert	1	T_C	18	±1	No
SPI	1	T_I	18	±1	No
Reservations B, C, D	3 *	T_{RB}, T_{RC}, T_{RD}	18	±1	Yes
Multisite lock-out	78	T_L	18	±1	No

* As required

<u>Note:</u> *All timers are capable of being restarted. On receipt of any start command, they run for their specified times. This occurs regardless of whether they are in the running or the non-running state at the time that the start command is received. A command to cancel a timer causes the timer to stop running and to return to its initial state in preparation for a subsequent start command.*

Mode S interrogations **shall** be accepted only if the address of the recipient is as defined in "a" or "b" below:

a. Discrete Address – The interrogation **shall** be accepted if the address extracted from the received interrogation is identical to the transponder's address and UF is not equal to 11.

b. All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation **shall** be accepted according to "i" below unless the lockout protocol is in effect. Mode S-Only All-Call **shall not** be accepted (no replies) when in the on-the-ground state (consistent with the CA, VS and FS fields).

c. ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P_4) **shall** be accepted unless the T_D timer is running or side lobe suppression is in effect or when in the "on-the-ground" state (consistent with the CA, VS and FS fields).

   Note: *The acceptance of ATCRBS/Mode S All Call interrogations may be disabled in a future version of these MOPS.*

d. ATCRBS-Only All-Call – A Mode S transponder **shall not** accept the ATCRBS-Only All-Call (0.8 microsecond P_4).

e. Lack of Reply Capability – The transponder **shall not** accept Mode S interrogations UF=4 or UF=5 if the code in the RR field is larger than 15.

f. Side Lobe Suppression – Suppression as described in §2.2.5.1 **shall** apply to responses to ATCRBS and ATCRBS/Mode S All-Call interrogations.

g. All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) containing an Interrogator Code (IC and CL fields) corresponding to the designator of a running T_L timer, the interrogation **shall not** be accepted unless the contained PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation **shall** be accepted if the T_D timer is not running or if the received PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition.

h. Formats for Which Transponder Is Not Equipped – The transponder **shall not** accept a Mode S format for which it is not equipped.

i. Stochastic All-Calls – Upon receipt of a Mode S-Only All-Call with a PR (§2.2.14.4.31) code other than 0 or 8, the transponder **shall** execute a random process. If the reply probability indicated by the outcome of the random process is less than or equal to the reply probability indicated by the value of PR and if no lockout condition applies (includes override, §2.2.18.2.4) and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition the transponder **shall** accept the interrogation.

   If the value of PR is 5 through 7 or 13 through 15, the interrogation **shall not** be accepted.

j. Mode S Reply Rate Limiting – Mode S interrogations **shall not** be accepted if the optional Mode S reply rate limit is exceeded.

k. Transaction Cycle – If the transponder is in a transaction cycle, it **shall not** accept interrogations.

The transaction cycle begins when the transponder has recognized an interrogation type and ends when the transponder has finished the reply or has aborted processing this interrogation.

Note: *A Mode S interrogation is recognized when the sync phase reversal has been detected. The transaction cycle ends when either the interrogation has been accepted and has been replied to, or when the interrogation has not been accepted because of wrong address, lockout, etc. An ATCRBS interrogation is recognized when a proper P_1 – P_3 interval has been detected and a following leading edge of a P_4 has not been detected. During ATCRBS suppression intervals recognition of P_1 – P_2 – P_3 intervals is suspended. In the interval between P_1 and an expected P_3, a transponder is not in a transaction cycle.*

2.2.18.2.3 Interrogation Reply Coordination

The transponder **shall** generate replies as follows, except when in the on-the-ground state:

Interrogations	**Replies**
ATCRBS Mode A	4096 Codes
ATCRBS Mode C	Altitude Codes
ATCRBS Mode A/Mode S All-Call	Reply is DF=11
ATCRBS Mode C/Mode S All-Call	Reply is DF=11
Mode S-only All-Call (UF=11)	Reply is DF=11

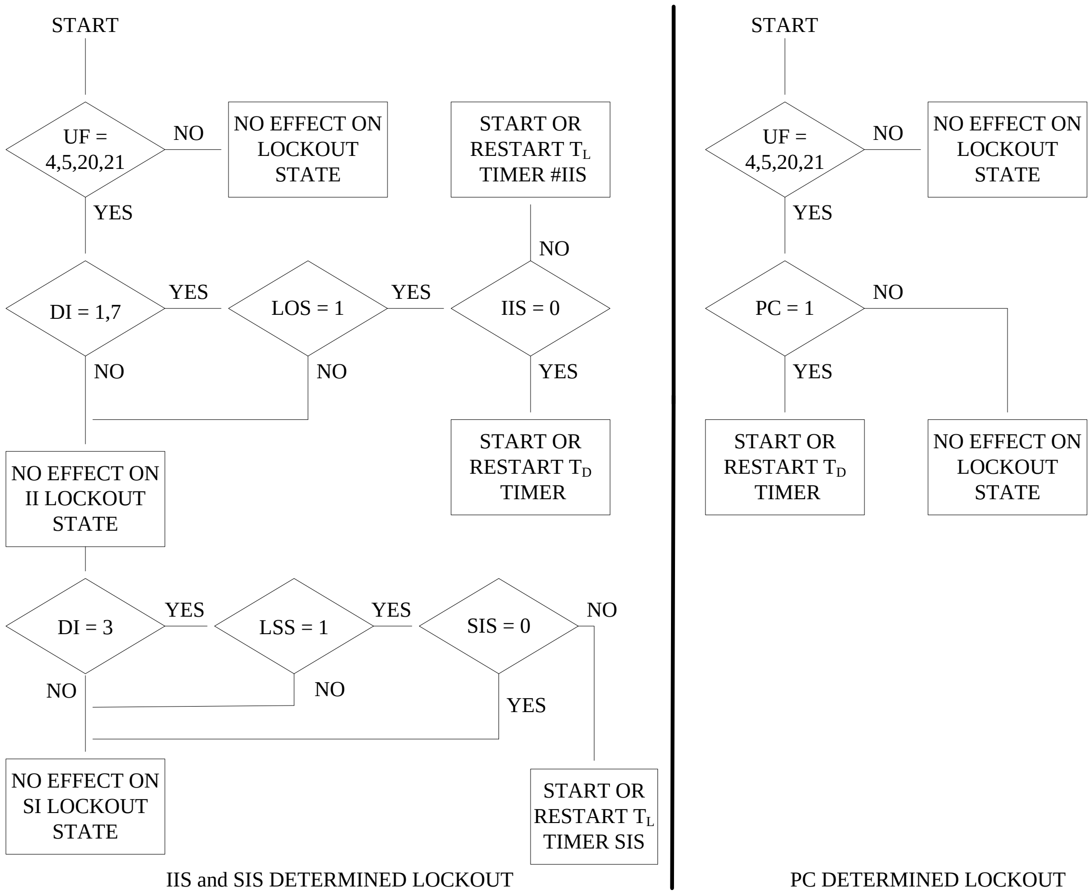
Note: *Transponders that simulate ATCRBS/Mode S All Call interrogations in self test/squitter transmission may occasionally open their window of non acceptance for this purpose coincident with an actual interrogation, thus generating a reply to the interrogation. Such coincidental acceptance periods may be considered tolerable, but must not exceed one percent of transponder operating time.*

2.2.18.2.4 Lockout Protocol (Figure 2-13)

Transponders can be prevented from accepting certain interrogations by command from an interrogator.

Non-Selective All-Call Lockout – On acceptance of an interrogation containing code 1 in the PC field or containing LOS=1 together with IIS=0 in the SD field or both of these code sets, the transponder **shall** start the T_D timer. This timer **shall** run for 18 ±1.0 seconds after the last received command.

Note: *Non-selective All-Call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. The non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected ATCRBS/Mode S All-Call interrogations from ATCRBS-Only All-Call interrogations because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.*



Note: For actions of T_D – T_L and IIS, see acceptance protocol.

Figure 2-13: All Transponders: Lockout Initiation

2.2.18.2.5 Multisite Lockout Protocol (Figure 2-13)

The multisite lockout command **shall** be transmitted in the SD field (§2.2.14.4.36). A lockout command for an II code **shall** be transmitted in an SD with DI=1 or DI=7. An II lockout command **shall** be indicated by LOS equals ONE in the presence of a non-zero interrogator identifier in the IIS subfield of SD. A lockout command for an SI code **shall** be transmitted in an SD with DI=3. An SI lockout **shall** be indicated by LSS (§2.2.19.2.1.1) equals ONE in the presence of a non-zero interrogator identifier in the SIS subfield of SD (§2.2.19.2.1). After a transponder has accepted an interrogation containing a multisite lockout command, that transponder **shall** commence to lock out (i.e., not accept) any Mode S-only All-Call interrogation which includes the identifier of the interrogator that commanded the lockout. The lockout timer (T_L) **shall** persist for an interval 18 ±1 seconds after the last acceptance of an interrogation containing the multisite lockout command. Multisite lockout **shall not** prevent acceptance of a Mode S-only All-Call interrogation containing PR codes 8 to 12. If a lockout command (LOS=1) is received together with IIS=0, it **shall** be interpreted as a non-selective all-call lockout.

Notes:

1. *Fifteen interrogators can send independent multisite II lockout commands. In addition, sixty-three interrogators can send independent SI lockout commands. Each of these lockout commands must be timed separately.*

2. *Multisite lockout (which uses only non-zero II codes) does not affect the response of the transponder to a Mode S-only All-Call interrogation containing II equals 0 or to Mode A/C/S All-Call interrogations.*

3. *Non-selective All-Call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. The non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected ATCRBS/Mode S All-Call interrogations from ATCRBS-Only All-Call interrogations because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.*

2.2.18.2.6 Acquisition Squitter Protocols

Mode S transponders **shall** transmit Acquisition squitters to facilitate acquisition.

a. Acquisition Squitter Format – The format used for the acquisition squitter transmissions **shall** be the All-Call reply, DF=11 using II=0 and SI=0 in generating the PI field.

b. Squitter Rate – Acquisition squitter transmissions **shall** be emitted at random intervals that are uniformly distributed over the range from 0.8 to 1.2 seconds using a time quantization no greater than 15 milliseconds relative to the previous acquisition squitter, with the following exceptions:

(1) The scheduled acquisition squitter **shall** be delayed if a mutual suppression interface is active.

Note: *A mutual suppression system may be used to connect on-board equipment operating in the same frequency band in order to prevent mutual interference. Squitter action resumes as soon as practical after a mutual suppression interval.*

(2) The scheduled acquisition squitter **shall** be delayed if the transponder is in a transaction cycle (see §2.2.18.2.2.k.).

(3) The scheduled acquisition squitter **shall** be delayed if an Extended Squitter is in process.

(4) Acquisition squitters **shall** only be transmitted when in the on-the-ground state if the transponder is not reporting the surface type of Mode S Extended Squitter or as specified in subparagraph c.

An acquisition squitter **shall not** be interrupted by link transactions after the squitter transmission has begun. A delayed acquisition squitter **shall** be transmitted as soon as the condition causing the delay no longer exists.

Note: *Extended Squitter applies to Level 2 or higher transponders so equipped.*

c. Conditions for Acquisition Squitter Transmission – The following applies to transponders transmitting Extended Squitters. When commanded to report the surface type formats by TCS commands (see §2.2.23.1.7), aircraft without automatic means of determining the on-the-ground condition, and aircraft with such means that are reporting airborne state, **shall** transmit acquisition squitters in addition to the surface Extended Squitter formats unless acquisition squitter transmission has been inhibited (subparagraph d.).

Note 1: *This action is taken to ensure TCAS acquisition in the event that the ground station inadvertently commands an airborne aircraft to report the surface Extended Squitter formats.*

Note 2: *A summary of the acquisition squitter transmission conditions is presented in the following table. In this table, Y indicates that the acquisition squitter is regularly broadcast, and N means that the acquisition squitter is suppressed.*

Note 3: *The condition of no transmission of any Extended Squitter can result from initialization with no position, velocity, or identity data available.*

Table 2-2: Acquisition Squitter Transmission Requirements

		Aircraft On-The-Ground Condition		
		Airborne	**Surface**	**Airborne or Surface**
Acquisition Squitter NOT Inhibited	No transmission of any Surveillance Type Extended Squitter	Y	Y	Y
	At Least one Surveillance Type Extended Squitter Transmitted	Y	N	Y
	Reporting Surface Format	Y	N	Y
Acquisition Squitter Inhibited	No transmission of any Surveillance Type Extended Squitter	Y	Y	Y
	At Least one Surveillance Type Extended Squitter Transmitted	N	N	N
	Reporting Surface Format	N	N	N

Notes:

1. *Y = regular transmission of acquisition squitters*
2. *N = acquisition squitter suppressed*
3. *Surveillance type Extended Squitters are airborne position, airborne velocity or surface position Extended Squitters*

d. Future Suppression of Regular Transmission of Acquisition Squitter Transponders equipped for Extended Squitter operation should have a means to disable acquisition squitters when Extended Squitters are being emitted. After regular acquisition squitter suppression has been implemented, the acquisition squitter **shall** continue to be broadcast by transponders if they are not emitting any Extended Squitters.

Notes:

1. *Provision of this means will facilitate the suppression of acquisition squitters when all TCAS units have been converted to receive the Extended Squitter.*
2. *Broadcast of acquisition squitters when no Extended Squitter is broadcast is necessary in order to ensure acquisition by TCAS.*
3. *A TCAS will need to retain the ability to receive the acquisition squitter even after that TCAS has been converted to receive the Extended Squitter.*

2.2.18.2.7 Flight Status and Vertical Status Protocols (Figure 2-17)

Mode S-equipped aircraft **shall** report details of their flight status. The source of and the rules for such reports are as follows:

a. <u>Alert</u> – The transponder **shall** transmit the 4096 identification code in ATCRBS Mode A replies and in the ID field of downlink format DF=5. This code can be changed by the pilot, and when a change is made an alert condition **shall** be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition **shall** be permanent. If the identification code is changed to any other value, the alert condition **shall** be temporary and self-canceling after 18 ±1 seconds (T_C timer). The T_C timer **shall** be retriggered and continued for 18 ±1 seconds after any change has been accepted by the transponder function. The alert condition **shall** be reported in the FS field. The permanent alert condition **shall** be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700.

<u>Note 1:</u> *Retriggering is performed to ensure that the ground interrogator obtains the desired Mode 3/A code before the alert condition is cleared.*

When the transponder transitions to normal operation (see §2.1.7.c) it **shall** initiate a temporary alert for 18 ±1 seconds.

b. <u>On-the-Ground Report</u> – The on-the-ground status of the aircraft **shall** be reported in the FS field and the VS field and the CA field. If a means for automatically indicating the on-the-ground condition (e.g., a weight on wheels or strut switch) is available at the transponder data interface, it **shall** be used as the basis for the reporting of vertical status. If a means for automatically indicating the on-the-ground condition is **not** available at the transponder data interface, the FS and VS codes **shall** indicate that the aircraft is airborne and the CA field **shall** indicate that the aircraft is either airborne or on-the-ground (CA=6).

c. <u>Validation of declared on-the-ground status</u>

<u>Note 2:</u> *For aircraft with an automatic means of determining vertical status, the CA field reports whether the aircraft is airborne or on the ground. ACAS II acquires aircraft using the short or Extended Squitter, both of which contain the CA field. If an aircraft reports on-the-ground status, that aircraft will not be interrogated by ACAS II in order to reduce unnecessary interrogation activity.*

For Aircraft with an automatic means for determining the on-the-ground condition, transponders that have access to at least one of the following parameters (ground speed, radio altitude, airspeed) **shall** perform the following validation check:

If the automatically determined air/ground condition is not available, or is "airborne," no validation **shall** be performed.

If the automatically determined air/ground condition is available, and the "on-the-ground" condition is being reported, then the air/ground condition **shall** be overridden and changed to "airborne" if:

Ground Speed > 100 knots OR Airspeed > 100 knots OR Radio Altitude > 50 feet

<u>Note 3:</u> *For Extended Squitter installations, the on-the-ground validation is optional for Aircraft reporting ADS-B Emitter Category Set "A" codes 0, 1 or 7 as defined in the latest version of RTCA DO-260B / EUROCAE ED-102A, §2.2.3.2.1.2.*

Note 4: *Modern aircraft with integrated avionics suites commonly contain sophisticated algorithms for determining the air/ground state based on multiple aircraft sensors. These algorithms are customized to the airframe and designed to overcome individual sensor failures. These algorithms are an acceptable means to determine the air/ground state and do not require additional validation.*

d. Special Position Identification – When manually selected, the transponder **shall** transmit the equivalent of the ATCRBS SPI in the FS field of surveillance replies DF=4, 5, 20, 21 and in the Surveillance Status Subfield (see §2.2.23.1.8) of Extended Squitter transmissions (DF=17) when they contain the airborne position report. This code **shall** be transmitted for 18 ±1 seconds (T_I timer) after initiation and can be reinitiated at any time.

2.2.18.2.8 Capability Reporting

The transponder **shall** transmit a "0" value in the three-bit CA (capability) field of an All-Call (DF=11) reply.

2.2.18.2.9 All-Call Reply Protocol

Upon acceptance of a Mode S-Only All-Call interrogation (UF=11) the transponder **shall** reply by overlaying the received II or SI code on parity according to §2.2.18.2.1, resulting in the PI field which **shall** be used in the reply (DF=11). Upon acceptance of an ATCRBS/Mode S All-Call interrogations the transponder **shall** generate the PI field using II=0.

2.2.18.2.10 Reply Content (Figure 2-18)

The information content of a Mode S reply **shall** reflect the conditions existing in the transponder after completion of all transponder processing of the interrogation soliciting that reply.

In the reply to UF=0, the transponder **shall** insert:

VS in bit 6.
RI in bits 14 to 17.
AC in bits 20 to 32.

In the reply to UF=4, AC **shall** be in bits 20 to 32. In the reply to UF=5, ID **shall** be in bits 20 to 32. In the reply to UF=11, AA **shall** be in bits 9 to 32.

In replies to UF=4 and UF=5, the transponder **shall** insert ZEROs in bits 9 through 13 in the DR field.

2.2.18.2.11 Data Handling and Interfaces

The transponder **shall** have the following data interfaces as described in §2.2.13:

Mode S Discrete Address (AA)
Maximum Airspeed (RI)
Pressure Altitude (AC)
4096 Identification Code (ID)
On-the-Ground Condition (FS, VS, CA)
Special Position Indicator (FS)

2.2.19 Minimum Level 2 Transponder Description

An overview of data link uses appears in §1.4.7. The following subparagraphs "a" through "g" provide a general description of data link transponders.

a. Formats

Messages appear in dedicated fields (MA, MB, MC, etc.) of some Mode S formats.

b. Participants

Uplink messages are generally directed to the pilot's attention. Downlink messages can be readouts of on-board data which do not need pilot intervention or can be messages deliberately sent by the pilot. ("Pilot" is to be understood as any of the flight deck crew.)

c. Peripherals

Peripherals, also called I/O devices, process and store messages received and/or to be transmitted. They translate received messages into visual or aural form, and messages to be transmitted, into agreed-upon binary coding. Peripherals can be contained within the transponder enclosure or can be separated from the transponder.

d. Interfaces

If peripheral separation as mentioned above is used, interfaces (see §2.2.13) **shall** be part of the transponder design.

e. Message Content, Specified

This document specifies message content only for standardized messages which have their data base within the transponder. These are the data link capability report (Register 10_{16}), and the aircraft identification report (Register 20_{16}) using Comm-B, and the transmission and acknowledgment subfields of the downlink ELM protocol (see §2.2.19.1.12.6, §2.2.19.1.13 and §2.2.20.1.1.1.6)

f. Message Content, NOT Specified

Message structure and coding for various data link applications will be found in the documents describing those services.

g. Protocol Overview

Data exchanges are always under control of the interrogator. Comm-A messages are sent directly to the transponder. Ground-initiated Comm-B replies are extracted from the transponder by suitable interrogation content. Air-initiated Comm-B messages are announced by the transponder and are transmitted in a subsequent reply only after authorization by the interrogator. Longer messages, either on the uplink or downlink, can be exchanged by the ELM protocol using Comm-C and Comm-D formats. The ELM protocol provides for the interrogator transmission of up to sixteen 112-bit message segments before requiring a reply from the transponder. It also allows a corresponding procedure for downlink ELM transmission.

Air-initiated Comm-B messages are announced to all interrogators and can be extracted by any interrogator. However, an individual interrogator can use the multisite protocol to reserve for itself the ability to close out (cancel) the Comm-B transaction. A similar coordination technique applies to the ELM protocol. A transponder can be instructed to identify the interrogator that has reserved the transponder for an ELM transaction. Only that interrogator can terminate the ELM transaction.

2.2.19.1 Minimum Level 2 Transponder Requirements

The operational functions described in §1.4.3.2 require that this transponder **shall**, in addition to the functions of the Level 1 transponder:

a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14). The format UF=16 is optional.

   Note: *UF=16 is supported by transponders connected to an on-board operational TCAS (see §2.2.22).*

b. Receive broadcast transmissions from sensors (§2.2.19.1.11).

c. Follow the protocols for:

   Comm-A (see §2.2.19.1.10).
   Comm-B (see §2.2.19.1.12).
   Comm-U/V (air-air) (see §2.2.19.1.16).
   Multisite message operation (see §2.2.19.2).
   Report Codes 4 through 7 in the CA field (see §2.2.14.4.6).
   TCAS crosslink capability (see §2.2.19.1.18).

Uplink Formats

Format #	UF								
0	0 0000	- 3 -	RL: 1	- 4 -	AQ: 1	DS: 8	- 10 -	AP: 24	. . . Short Special Surveillance
4	0 0100	PC : 3	RR : 5	DI : 3	SD : 16	AP: 24			. . . Surveillance, Altitude Request
5	0 0101	PC : 3	RR : 5	DI : 3	SD : 16	AP : 24			. . . Surveillance, Identity Request
11	0 1011	PR : 4	IC : 4	CL : 3	- 16 -	AP : 24			. . . Mode S-Only All-Call
16	1 0000	- 3 -	RL: 1	- 4 -	AQ: 1	- 18 -	MU: 56	AP: 24	. . . Long Special Surveillance
20	1 0100	PC : 3	RR : 5	DI : 3	SD : 16	MA : 56	AP: 24		. . . Comm-A, Altitude Request
21	1 0101	PC : 3	RR : 5	DI : 3	SD : 16	MA : 56	AP: 24		. . . Comm-A, Identity Request

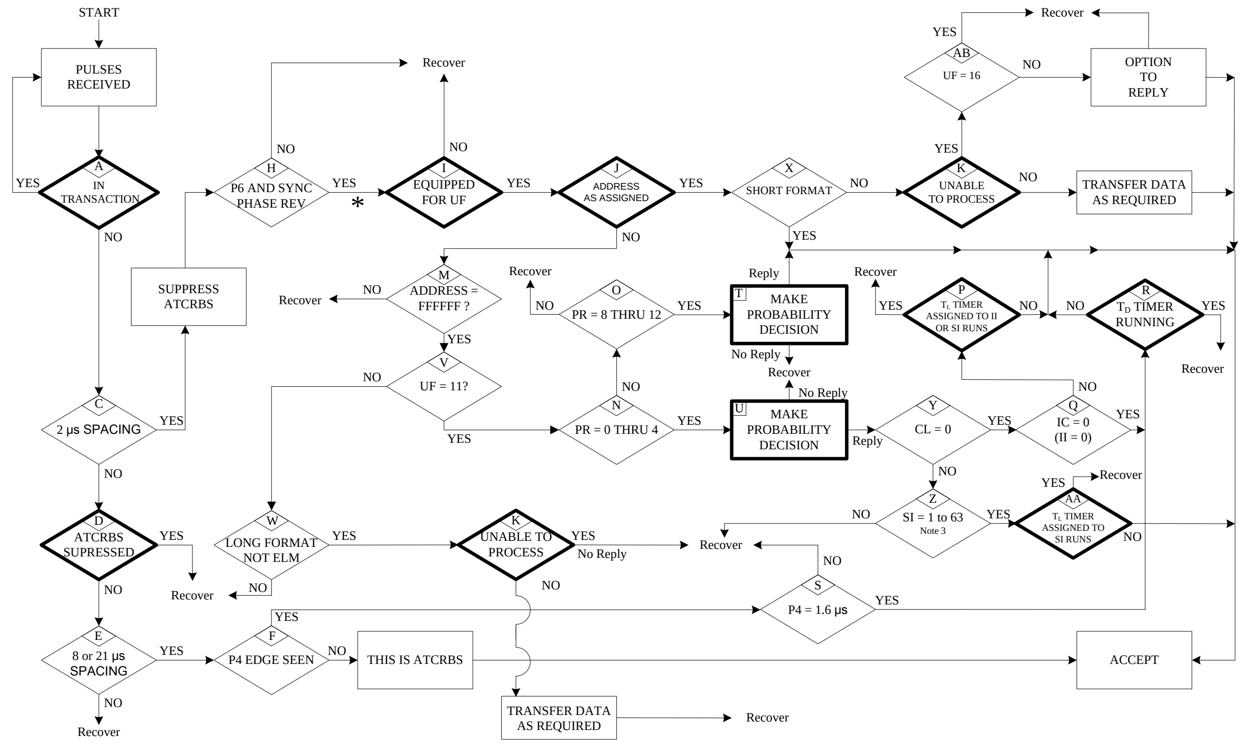
Downlink Formats

Format #	DF										
0	0 0000	VS: 1	CC: 1	-1-	SL: 3	-2-	RI: 4	-2-	AC: 13	AP: 24	. . . Short Special Surveillance
4	0 0100	FS : 3	DR : 5	UM : 6	AC : 13	AP: 24					. . . Surveillance, Altitude
5	0 0101	FS : 3	DR : 5	UM : 6	ID : 13	AP : 24					. . . Surveillance, Identity
11	0 1011	CA : 3	AA : 24	PI : 24							. . . All-Call Reply
16	1 0000	VS: 1	-2-	SL: 3	-2-	RI: 4	-2-	AC: 13	MV: 56	AP: 24	. . . Long Special Surveillance
17	1 0001	CA : 3	AA : 24	ME : 56	PI: 24						. . . Extended Squitter
20	1 0100	FS: 3	DR: 5	UM: 6	AC: 13	MB: 56	AP: 24 / DP: 24				. . . Comm-B, Altitude (see Note 4)
21	1 0101	FS : 3	DR : 5	UM : 6	ID : 13	MB : 56	AP: 24 / DP: 24				. . . Comm-B, Identity (see Note 4)

Figure 2-14: All Level 2 Transponders: Formats

Notes:

1. *Uplink and downlink formats 16 are used in TCAS applications.*
2. *The PC, RR, DI and SD fields do not apply to a Comm-A Broadcast Interrogation.*
3. *Downlink format 17 is only used for Extended Squitter and is optional.*
4. *The Data Parity (DP) (see §2.2.14.4.12) is used if it has been commanded by the OVC (see §2.2.19.2.1.1.h) in accordance with §2.2.19.1.12.1 and §2.2.19.1.12.2.*



<u>Figure 2-15:</u> Level 2 Transponders: Interrogation Acceptance

<u>Notes:</u>

1. Bold boxes indicate Transponder States.

*2. * = Start of Mode S transaction cycle.*

3. For SI=1, CL=1 and IC=1. For SI=63, CL=4 and IC=15.

2.2.19.1.1 Interrogation Acceptance Protocol (Figure 2-15)

The interrogation acceptance protocol of §2.2.18.2.2 **shall** be used with the following additions:

a. An interrogation may optionally be accepted or not accepted if the corresponding data buffer (see §2.2.13.3.1) is full.

b. An interrogation **shall** be accepted as a "broadcast" if the UF format code is 20, 21 or 16 (if so equipped), and if an ALL ONEs address is decoded.

c. Only formats for which the transponder is designed, and to which it can reply, **shall** be accepted.

2.2.19.1.2 Error Protection

The parity algorithm described in §2.2.18.2.1 **shall** be expanded to include 112-bit transmissions.

2.2.19.1.3 Information Transfer

The minimum Level 2 transponder **shall** be able to transfer information to and from the appropriate data sinks (destinations) and sources (see §2.2.13 and §2.2.19.c and §2.2.19.d).

2.2.19.1.4 Interrogation-Reply Coordination (Figure 2-16)

The transponder **shall** generate replies to interrogations as follows:

Interrogation	Reply
ATCRBS Mode A (see Note)	4096 Code
ATCRBS Mode C (see Note)	Altitude Code
ATCRBS/Mode S All-Calls (see Note)	DF=11
UF=4 and UF=5	as below
UF=11 (see Note)	DF=11
UF=20 and UF=21	as below
Broadcast	None

Note: *The transponder does not reply when the conditions of §2.2.18.2.3 apply.*

Upon acceptance of an interrogation with UF codes 0 or 16, the transponder **shall** reply with DF=0, if RL=0, and **shall** reply with DF=16, if RL=1.

If the transponder is not equipped with the optional long air-air formats UF=DF=16, it **shall not** accept UF=16 and it **shall not** reply to UF=0 containing RL=1.

Upon acceptance of an interrogation with a UF code of 4, 5, 20 or 21, the transponder **shall** examine the RR code and generate downlink formats as follows:

Uplink Format, UF	RR Code	Downlink Format, DF
4	0 through 15	4
5	0 through 15	5
20	0 through 15	4
21	0 through 15	5
4	16 through 31	20
5	16 through 31	21
20	16 through 31	20
21	16 through 31	21

Note: *In effect, the first bit of the RR field determines the length of the required reply.*

Interrogation UF	Special Conditions	Reply DF
0	RL = ZERO (0)	0
	RL = 1	16*
4	RR less than 16	4
	RR equal to or greater than 16	20
5	RR less than 16	5
	RR equal to or greater than 16	21
11	Transponder locked out to interrogator identifier II or SI	No reply
	Stochastic reply test fails	No reply
	Otherwise	11
16	RL = ZERO (0)	0
	RL = 1	16*
	Broadcast Address	No reply
20	RR less than 16	4
	RR equal to or greater than 16	20
	Broadcast Address	No reply
21	RR less than 16	5
	RR equal to or greater than 16	21
	Broadcast Address	No reply
others		No reply

*No reply if transponder is not equipped to send DF=16

A broadcast address consists of 24 ONEs in uplink formats UF=20 and UF=21 and also, if so equipped, for UF=16

Figure 2-16: All Level 2 Transponders: Coordination

2.2.19.1.5 Lockout Protocols (Figure 2-13)

Lockout commands **shall not** be accepted if they occur within a broadcast interrogation.

In addition to the rules in §2.2.18.2.4, lockout commands **shall** be accepted if they appear in interrogations UF=20 and UF=21.

2.2.19.1.6 Flight and Vertical Status Protocols (Figure 2-17)

The FS report (see §2.2.18.2.7) **shall** also appear in DF=20 and DF=21 and VS **shall** also appear in DF=16.

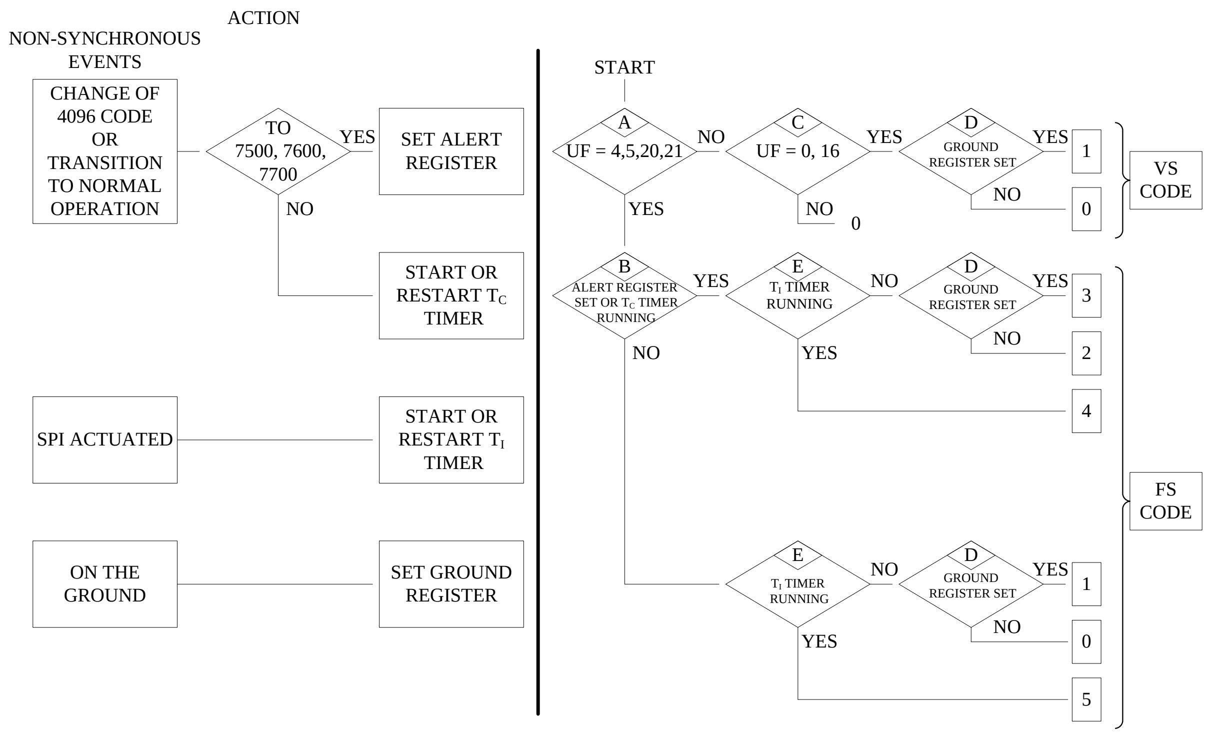


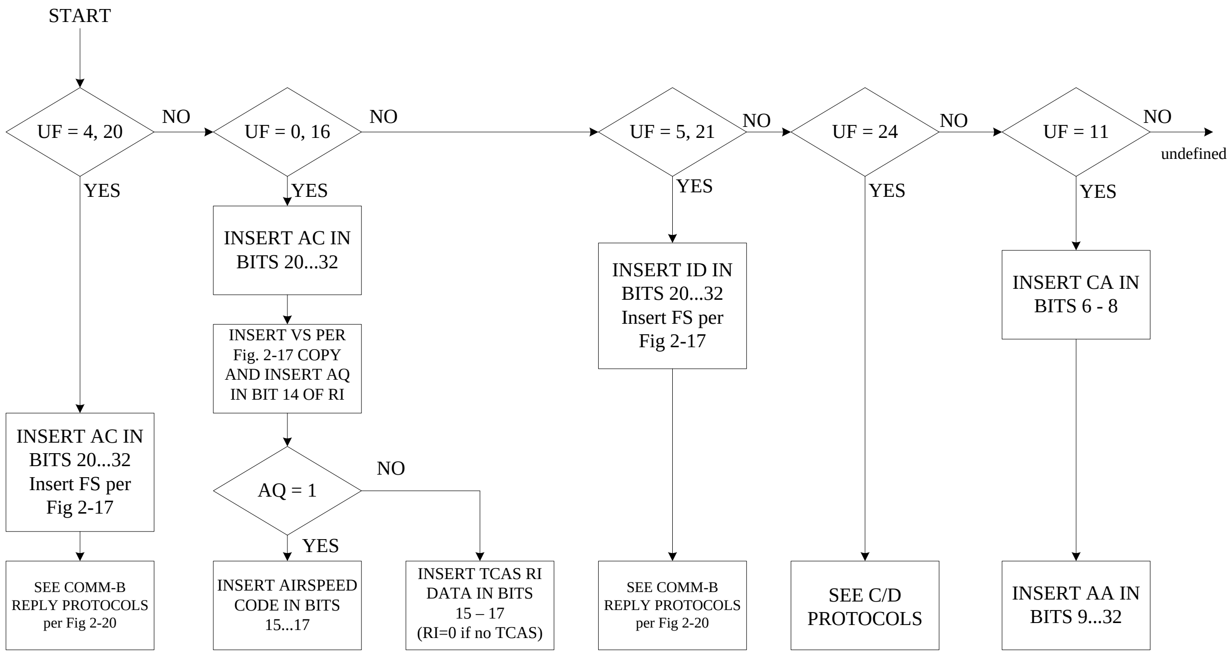
Figure 2-17: **All Transponders: FS and VS Protocol**

2.2.19.1.7 Capability Report

The transponder **shall** reply with a non-zero value of CA (see §2.2.14.4.6) in the capability field of DF=11 and DF=17, indicating that further data link information is available in a data link capability report (§2.2.19.1.12.6).

2.2.19.1.8 Reply Content (Figure 2-18)

The reply content summary of §2.2.18.2.10 **shall** apply. Additionally, the rules applying to formats UF=4, UF=5 **shall** also apply to formats UF=20 and UF=21 respectively.



<u>Figure 2-18:</u> All Transponders: Reply Content

2.2.19.1.9 UM Protocol (Figure 2-19)

The UM field **shall** support functions for the multisite protocol. The following paragraphs contain the requirements and descriptions of the protocol.

a. Field description is in §2.2.14.4.41.

b. If DI=1, multisite information may be requested as specified in §2.2.19.2.1.2.

c. If no request appears, direct Comm-B/D information may appear in UM as specified in §2.2.19.2.3.2 and §2.2.20.2.3.2.

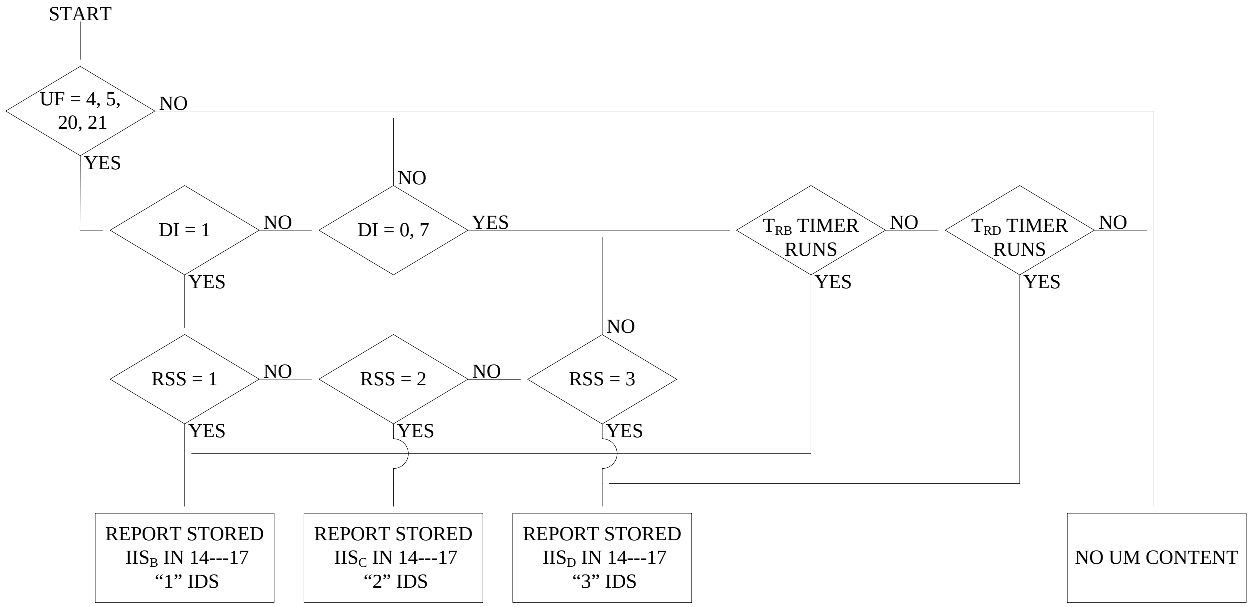


Figure 2-19: All Level 2 Transponders: UM Protocol

Note: *For a Level 5 transponder, there is a T_{RB} and T_{RD} timer for each IIS.*

2.2.19.1.10 Comm-A Protocol

Comm-A is the transmission of information from the ground to the aircraft by formats UF=20, 21. In addition to the content of the corresponding short formats (UF=4, 5) the Comm-A formats contain the additional 56-bit field MA.

The Level 2 transponder **shall** direct the content of received Comm-A formats to the interface (see §2.2.13.2).

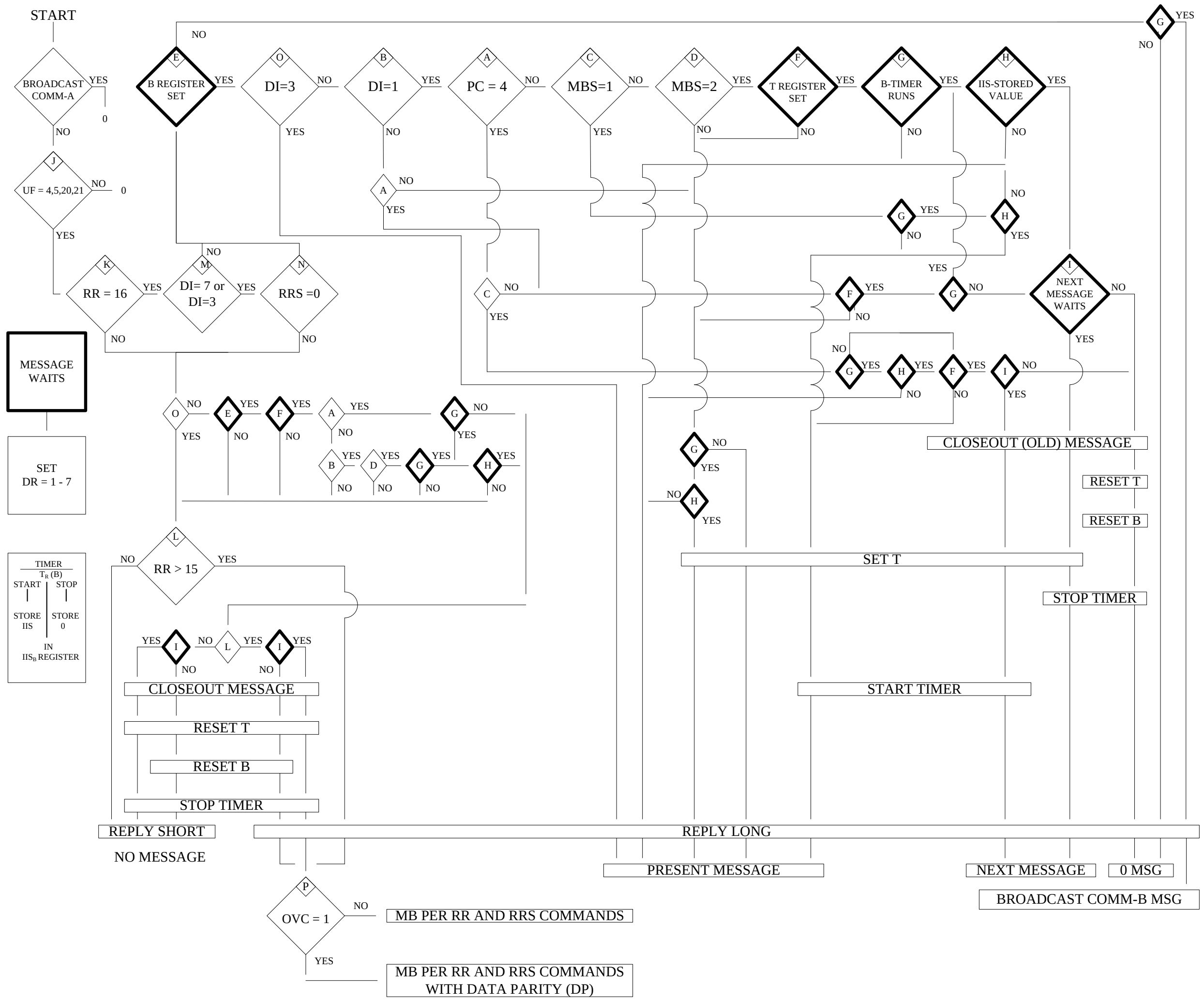
2.2.19.1.11 Broadcast Protocol

If a broadcast interrogation has been accepted (see §2.2.19.1.1), the minimum data link transponder **shall** make that information available at the appropriate interface.

Other transponder functions **shall not** be affected, and a reply **shall not** be transmitted. The transponder does not process the control fields of a Comm-A broadcast interrogation, so the 27 bits following the UF field are also available for user data.

2.2.19.1.12 Comm-B Protocol (Figure 2-20)

Comm-B is the transmission of information from the aircraft to the ground and follows the general protocol as outlined in §2.2.19.g. Figure 2-20 is a flow chart containing the ground-initiated Comm-B readout, the procedures for air-initiated Comm-B transactions and the multisite procedures.



<u>Figure 2-20:</u> All Data Link Transponders: B-Protocol

<u>Notes:</u>

1. Bold boxes indicate Transponder States.
2. “0” indicates termination of the process.
3. The T-Register (see Figure 2-24) indicates whether the message has been read at least once.
4. The T-Register is reset when the B-Timer expires.
5. The B-Timer does not expire for a multisite-directed Comm-B message.
6. Additional processing for multisite-directed Comm-B transmissions is defined in §2.2.19.2.3.2.
7. IIS is only defined if DI=0, 1 or 7.
8. This figure does not include the Enhanced Data Link Protocol features.
9. The B-Timer is started only if IIS≠0.
10. The PC field processing must be completed before any SD field processing.
11. Additional instances of the same decision diamond are represented by a small diamond containing only the letter.

2.2.19.1.12.1 Data Source Designators

When Comm-B information to be transmitted resides in data sources that are part of the Mode S installation, the data sources **shall** be identified by the BDS code of §2.2.14.4.21.b. The interrogator uses the RR field of surveillance and Comm-A interrogations to designate the BDSl of the data source from which the reply should originate. BDS1 is represented by the last 4 bits (bits 10 – 13) of the received RR code (see §2.2.14.4.35).

If the DI code of the Comm-B requesting interrogation is not equal to 3 or 7, the BDS2 code of the desired reply source **shall** be "0."

If the "DI" code of the Comm-B requesting interrogation is 0, 3, or 7, the "SD" contains the "OVC" in accordance with §2.2.19.2.1.1.h. If the "OVC" is equal to "1," then the reply to the interrogation **shall** contain the "DP" (Data Parity) field in accordance with §2.2.14.4.12. If the "OVC" is equal to "0," then the reply to the interrogation **shall** contain the "AP" (see §2.2.14.4.4).

2.2.19.1.12.2 Extended Data Source Designators

The interrogator can request data to be read out from a source more specifically defined by both BDS1 and BDS2. The readout is initiated by transmitting, in addition to the BDS1 code in RR, the BDS2 code in the SD field. See §2.2.19.2.1.1 for definitions of subfields in SD.

For transponders that support the Overlay Command Capability, if the "DI" code of the Comm-B requesting interrogation is 0, 3, or 7, the "SD" contains the "OVC" in accordance with §2.2.19.2.1.1.h. If the "OVC" is equal to "1," then the reply to the interrogation **shall** contain the "DP" (Data Parity) field in accordance with §2.2.14.4.12. If the "OVC" is equal to "0," then the reply to the interrogation **shall** contain the "AP" (see §2.2.14.4.4).

2.2.19.1.12.3 Ground-Initiated Comm-B

To read out data aboard the aircraft, the interrogator will transmit the appropriate data designators and the transponder **shall** insert the data according to §2.2.19.1.12.1 or §2.2.19.1.12.2.

2.2.19.1.12.4 Air-Initiated Comm-B

An air-initiated Comm-B sequence **shall** start upon the acceptance of a message intended for delivery to the ground sensor. After receipt of this message, the transponder **shall** insert codes 1 or 3 in the DR field of a surveillance or Comm-B reply, DF=4, 5, 20, 21. On receipt of this announcement, the interrogator transmits code 16 with DI≠7 or with DI=7 and RRS=0 in the RR field of a subsequent interrogation. This includes when DI=4, 5 or 6, which are currently reserved. Receipt of this code by the transponder **shall** constitute the authorization to transmit the data. The resulting MB field contains a code identifying the content of the field. This reply, and others following it, **shall** continue to contain codes 1 or 3 in the DR field. After the message has been transmitted at least once in response to an interrogation using non-selective protocols and after closeout is received (Code 4 in the PC field) in UF=4, 5, 20, 21, the transaction **shall** be closed out and the DR code belonging to this message immediately removed. Another message waiting to be transmitted can then set the DR code to 1 or 3 so that the reply can contain the announcement of this next message. If RR=16 with DI≠7, or with DI=7 and RRS=0, is received while no message is waiting to be transmitted, the reply **shall** contain all ZEROs in the MB field. An interrogation with DI=3 **shall not** affect the state of the Air-Initiated Comm-B protocol.

2.2.19.1.12.5 Comm-B Broadcast

Note: *A Comm-B broadcast is a message directed to all active interrogators in view. Messages are alternately numbered 1, 2 and are available for 18 seconds unless a waiting air-initiated Comm-B interrupts the cycle. Interrogators have no means to cancel the Comm-B broadcast.*

A Comm-B broadcast starts, when no air-initiated Comm-B transaction is in effect, with the insertion of DR codes 4, 5, 6 or 7 into downlink transmissions of DFs 4, 5, 20, 21 and with the starting of the B-timer. On receipt of the above DR codes, interrogators may extract the broadcast message by transmitting RR=16 with DI≠3 or 7, or with DI=3 or 7 and RRS=0 in subsequent interrogations. When the B-timer runs out after 18 ±1 seconds, the transponder will reset the DR codes as required, will discard the previous broadcast message and change from 1 to 2 (or vice versa) the broadcast message number.

If an air-initiated Comm-B transaction is initiated during the broadcasting interval (i.e., while the B timer is running), the B timer is stopped and reset, the appropriate code is inserted into the DR field and the Comm-B transaction proceeds per Figure 2-20. The previous Comm-B broadcast message remains ready to be reactivated for 18 ±1 seconds after conclusion of the air-initiated Comm-B transaction.

2.2.19.1.12.6 Data Link Capability Report

The data link capability report provides the interrogator with a description of the data link capability of the Mode S installation. The subfield definitions of the Data Link Capability Report are contained in Appendix B. The report is obtained by a ground-initiated Comm-B, containing RR=17 (see §2.2.19.1.12.3).

2.2.19.1.12.6.1 Subfields in MB for Data Link Capability Report

The subfields within MB of the data link capability report are:

BDS1 Code “1” is assigned to this 4-bit (bits 33 – 36) subfield for all data link capability reports.

BDS2 is a 4-bit (bits 37 – 40) subfield. The basic report uses BDS2=0.

2.2.19.1.12.6.2 Coding of the Data Link Capability Report

BDS1: 1 = Data Link Report

BDS2: 0 = Basic Report

For AIS capability reporting in the Data Link Capability Report, see §2.2.24.

<u>SCS:</u> This 1-bit (bit 66) squitter capability subfield **shall** report the capability of the transponder to transmit Extended Squitter position reports. It **shall** be set to ONE if GICB Registers 05_{16} and 06_{16} have been updated within the last 10 ±1 seconds. Otherwise it **shall** be set to ZERO. The internal insertion of data by the transponder into these registers (altitude and surveillance status) **shall not** qualify as a register update for this purpose.

Note: *GICB Registers 05_{16} and 06_{16} are used for the Extended Squitter airborne and surface position reports, respectively.*

SIC: This one bit (bit 67) SI capability subfield **shall** report the capability of the transponder to process SI codes. It **shall** be set to ONE for transponders with SI code capability. Otherwise it **shall** be set to ZERO.

OCC: This one bit (bit 47) Overlay Command Capability subfield **shall** report the capability of the transponder to include the Data Parity (see §2.2.14.4.12) downlink field when commanded by the interrogator (§2.2.19.2.1.1.h). It **shall** be set to ONE for transponders with Overlay Command Capability. Otherwise, it **shall** be set to ZERO.

Other bits are reserved for TCAS (see §2.2.22.1.2.2).

2.2.19.1.12.6.3 Updating of the Data Link Capability Report

At intervals not exceeding four seconds, the transponder compares the current basic data link capability status with that last reported and if a difference is noted, initiates a revised basic data link capability report by Comm-B broadcast for BDS1=1 and BDS2=0.

The transponder **shall** initiate, generate and announce the revised basic data link capability report even if the aircraft data link capability is degraded or lost. To support this requirement, the transponder **shall** set the BDS subfield for the basic data link capability report.

Note: *The setting of the BDS code by the transponder ensures that a broadcast change of the capability report will contain the BDS code for all cases of data link failure (e.g., the loss of the transponder data link interface).*

2.2.19.1.13 Aircraft Identification Reporting and AIS Aircraft Identification Subfield in MB

This subsection contains baseline aircraft identification requirements. More detailed requirements for implementation are provided in §2.2.24 as part of the Elementary Surveillance (ELS).

If a transponder is equipped for AIS reporting (Aircraft Identification Reporting), it **shall** report the information in the AIS subfield as described below.

a. Aircraft Identification Reporting

If so equipped, the transponder **shall** report the aircraft identification (aircraft radio call sign) used in the flight plan. This may be either the trip number assigned to commercial flights or the aircraft registration number, where applicable.

Note: *A firm requirement exists for the AIS feature in European Airspace. In such usage, the identification number entered in field 7 of the ICAO flight plan format **shall** be transmitted in the AIS subfield.*

b. AIS Aircraft Identification Subfield in MB

If a surveillance or Comm-A interrogation (UF=4, 5, 20, 21) contains RR=18 and DI does not equal 3 or 7, or DI equals 3 or 7 and RRS=0, the transponder **shall** report its aircraft identification number in the 48-bit (41-88) AIS subfield in MB.

c. Coding of the AIS Subfield

The MB field containing the AIS subfield **shall** be coded as follows:

Msg Bit #	33 -- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 -- 76	77 -- 82	83 -- 88
MB Bit #	1 -- 8	9 -- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
	BDS	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8

Note: *Aircraft Identification coding permits up to eight characters.*

The BDS code for the Aircraft Identification message **shall** be BDS1=2 and BDS2=0.

Each character **shall** be coded as a six-bit subset of the ICAO 7-unit coded character set (ICAO Annex 10) as illustrated in the following table. The character code **shall** be transmitted with the most significant bit b6 first. The reported aircraft code **shall** begin with the left-most character, character 1 (abbreviated as Ch 1 in the above diagram). Characters **shall** be coded consecutively without an intervening SPACE code. Any unused character spaces at the end of the subfield **shall** contain a SPACE character code.

d. Aircraft Identification Capability Reporting

Transponders that respond to a ground-initiated request for aircraft identification **shall** report this capability in the Data Link Capability Report according to §2.2.19.1.12.6.2.

e. Change of Aircraft Identification

If the aircraft identification reported in the AIS subfield is changed in flight, then the transponder **shall** report the new identification to the ground by use of the Comm-B Broadcast Message protocol.

The transponder **shall** initiate, generate and announce the revised Aircraft Identification report even if the interface supplying the Aircraft Identification data is degraded or lost. To support this requirement, the transponder **shall** set the BDS subfield for the Aircraft Identification report.

f. Six-Bit Character Set for Coding Aircraft Identification in the AIS Subfield

				b_6	0	0	1	1
				b_5	0	1	0	1
b_4	b_3	b_2	b_1					
0	0	0	0			P	SP	0
0	0	0	1		A	Q		1
0	0	1	0		B	R		2
0	0	1	1		C	S		3
0	1	0	0		D	T		4
0	1	0	1		E	U		5
0	1	1	0		F	V		6
0	1	1	1		G	W		7
1	0	0	0		H	X		8
1	0	0	1		I	Y		9
1	0	1	0		J	Z		
1	0	1	1		K			
1	1	0	0		L			
1	1	0	1		M			
1	1	1	0		N			
1	1	1	1		O			

SP - SPACE code

2.2.19.1.14 Linked Comm-A Coding

Peripherals attached to the Level 2 transponder may use the linked Comm-A protocol. The transponder is transparent to this protocol.

2.2.19.1.15 Multisite Message Protocol

The Level 2 transponder **shall** use the multisite message protocol of §2.2.19.2 as it applies to Comm-B operation.

2.2.19.1.16 Comm-U/V Protocol

The TCAS compatible transponder has the optional capability to receive, store and process information contained in the MU field of UF=16 and return the result of such process in the MV field of subsequent replies.

The protocol described in §2.2.18.2.10 applies to the first 32 bits of UF=16 and DF=16.

The protocol for the contents of the MU and MV fields will be as prescribed for that service.

2.2.19.1.17 Data Handling and Interfaces

In addition to the interfaces described in §2.2.18.2.11, the Level 2 transponder **shall** have interfaces for indirect data as specified in §2.2.13.2.

2.2.19.1.18 TCAS Crosslink Protocol

In response to a UF=0 with RL=1 (see §2.2.14.4.34) and DS≠0 (see §2.2.14.4.14), the transponder **shall** reply with a DF=16 reply in which the MV field **shall** contain the contents of the ground-initiated Comm-B register designated by the DS value. If the requested Register is not supported by the aircraft installation, then the transponder **shall** reply with an MV field containing ALL ZEROs. In response to a UF=0 with RL=1 and DS=0, the transponder **shall** reply with a DF=16 with an MV field of ALL ZEROs. Receipt of a UF=0 with DS non-zero but RL=0 **shall** have no associated TCAS crosslink action, and the transponder **shall** reply per §2.2.14.4.34.

2.2.19.2 The Multisite Message Protocol

Under certain circumstances it may be necessary for several Mode S interrogators, which have overlapping coverage, to operate without being in direct communication with each other. The multisite protocols described herein provide a means to prevent conflicts.

All multisite protocols are covered in the following paragraphs. However, only the Comm-B protocol **shall** apply to the Level 2 transponders.

2.2.19.2.1 Multisite Data Formats

2.2.19.2.1.1 Subfields in SD

The SD field (see §2.2.14.4.36) contains information as follows:

a. If the DI code is 0, 1 or 7:

   IIS: The 4-bit (17 – 20) Interrogator Identifier Subfield contains the self-identification code of the interrogator which is numerically identical to the II code transmitted by the same interrogator in the Mode S-Only All-Call. IIS codes are assigned to interrogators and range from 0 through 15; IIS=0 is not a valid interrogator identifier for multisite purposes.

b. If the DI=l:

   MBS: The 2-bit (bits 21 and 22) Multisite Comm-B Subfield has been assigned the following codes:

Code	Description
0	No Comm-B action
1	Comm-B reservation
2	Comm-B closeout

MES: The 3-bit (bits 23 – 25) Multisite ELM Subfield contains reservation and closeout commands for ELM as follows:

Code	Description
0	No ELM action
1	Comm-C reservation
2	Comm-C closeout
3	Comm-D reservation
4	Comm-D closeout
5	Comm-C reservation and Comm-D closeout
6	Comm-C closeout and Comm-D reservation
7	Comm-C and Comm-D closeouts

RSS: The 2-bit (bits 27 – 28) Reservation Status Subfield can request the transponder to report its reservation status in the UM field. The following codes have been assigned:

Code	Description
0	No request
1	Report Comm-B reservation status in UM
2	Report Comm-C reservation status in UM
3	Report Comm-D reservation status in UM

c. If the DI code is 1 or 7:

LOS: The 1-bit (bit 26) Lockout Subfield, if set to ONE, initiates a multisite All-Call lockout to Mode S-Only All-Calls (UF=11) from the interrogator indicated in IIS of the same interrogation. If LOS is set to ZERO no change in lockout state is commanded.

TMS: Tactical Message Subfield, subfield in SD 4 bits, 29 through 32. This subfield is used for identifying linkage of Comm-A messages, with "0" indicating an unlinked message. Coding for this field is described in Appendix C, §C.2.2.7.

d. If the DI=7:

RRS: Reply Request, subfield in SD, 4 bits, 21 through 24.

Coding: Corresponding to the requested BDS2 code. (See note in §2.2.14.4.35).

e. If the DI=2, the SD field is used for Extended Squitter surface control (see §2.2.23.1.7).

f. If the DI=3:

SIS: The 6-bit (bits 17 – 22) surveillance identifier subfield in SD **shall** contain an assigned SI code of the interrogator (see §2.2.14.4.37).

LSS: The 1-bit (bit 23) lockout surveillance subfield if set to ONE **shall** signify a multisite lockout command from the interrogator indicated in SIS. LSS set to ZERO **shall** be used to signify that no change in lockout state is commanded.

RRS: This 4-bit (bits 24 – 27) reply request subfield in SD **shall** be coded as specified in subparagraph d.

g. If DI=4, 5 or 6 then the SD field has no meaning and **shall not** impact other transaction cycle protocols. These DI codes remain reserved until future assignment of the SD field.

h. If DI=0, 3 or 7:

In addition to the requirements provided above, the “SD” **shall** contain the following:

“OVC”: The 1-bit (bit 28) “Overlay Command” subfield in “SD” is used by the interrogator to command that the Data Parity (“DP”) (see §2.2.14.4.12) be used in the resulting reply to the interrogation in accordance with §2.2.19.1.12.1 and §2.2.19.1.12.2.

When DI=1, PC field processing **shall** be completed before processing the SD field.

Note 1: *If SD field processing were to be performed before PC field processing in an interrogation containing a Comm–B close-out in the PC field and a request or a multisite reservation in the SD field, the results would be incorrect.*

Note 2: *Structure of SD if:*

Structure of SD, if:	Position	Number of Bits	Subfield
DI=0	17 – 20	4	IIS
	21 – 27	7	Reserved
	28	1	OVC
	29 – 32	4	Reserved
DI=1	17 – 20	4	IIS
	21 – 22	2	MBS
	23 – 25	3	MES
	26	1	LOS
	27 – 28	2	RSS
	29 – 32	4	TMS
DI=2	17 – 20	4	Reserved
	21 – 23	3	TCS
	24 – 26	3	RCS
	27 – 28	2	SAS
	29 – 32	4	Reserved
DI=3	17 – 22	6	SIS
	23	1	LSS
	24 – 27	4	RRS
	28	1	OVC
	29 – 32	4	Reserved
DI=7	17 – 20	4	IIS
	21 – 24	4	RRS
	25	1	Reserved
	26	1	LOS
	27	1	Reserved
	28	1	OVC
	29 – 32	4	TMS

2.2.19.2.1.2 Subfields in UM for Multisite Protocols

If a surveillance or Comm-A interrogation (UF=4, 5, 20, 21) contains DI=1 and RSS equals other than “0,” the following subfields will be inserted into the reply by the transponder.

If the above interrogation contains DI=0 or 7, or when DI=1 and RSS=0, the transponder **shall** insert IIS and IDS codes according to a Comm-B reservation if such reservation exists or is presently requested. In the absence of a Comm-B reservation, IIS and IDS codes for an existing or requested Comm-D reservation **shall** be inserted.

IIS: The four-bit (bits 14 – 17) Interrogator Identifier Subfield reports the identity of the interrogator that has made a multisite reservation.

IDS: The two-bit (bits 18 – 19) Identifier Designator Subfield reports the type of reservation made by the interrogator identified in IIS. Assigned coding is:

Code	Description
0	no information available
1	Comm-B reservation active
2	Comm-C reservation active
3	Comm-D reservation active

2.2.19.2.2 Multisite Common Protocols

The multisite timers and the interrogator identity report are common to all multisite message protocols.

2.2.19.2.2.1 Multisite Timers

The multisite protocols require three timers in the transponder:

B-timer for Comm-B – (T_{RB})

C-timer for Comm-C – (T_{RC})

D-timer for Comm-D – (T_{RD})

Each multisite timer **shall** run for 18 ±1 seconds after starting or restarting and is used for automatic closeout of the respective message type.

Note: *Each timer can be stopped (reset) on command from the ground.*

2.2.19.2.2.2 Interrogator Identity Report

Transponders **shall** insert the interrogator identifier into the UM field of the reply according to the coding of RSS.

2.2.19.2.3 Multisite Comm-B Protocol (Figure 2-20)

The multisite Comm-B protocol augments the standard Comm-B protocol and when not in use **shall not** modify the standard process in any way.

2.2.19.2.3.1 Multisite Comm-B Reservation

When the multisite protocol is in use, an interrogator extracts an air-initiated Comm-B by transmitting a surveillance or Comm-A interrogation containing:

RR	=	16 (read air-initiated Comm-B)
DI	=	1 (multisite SD format)
IIS	=	Interrogator's site number
MBS	=	1 (Comm-B reservation request)

The interrogator may also transmit:

RSS=1 (Comm-B reservation status request)

A multisite Comm-B reservation is invalid and **shall not** be granted by the transponder unless an air-initiated Comm-B message is waiting to be transmitted and the requesting interrogation contains RR=16, DI=1, MBS=1, IIS is not zero and the B timer is not running.

Transponder protocol procedures **shall** depend upon the state of the B-timer as follows:

a. B-timer not running

   Store IIS for Comm-B.

   Start B-timer.

b. B-timer running and interrogator's IIS equals stored Comm-B IIS

   Restart B-timer.

c. B-timer running and interrogator's IIS is not equal to stored Comm-B IIS

   No change to stored IIS or B-timer.

Note: *When an interrogator asks for Comm-B reservation status and receives its own site number in the UM field of the reply to an interrogation that contained the multisite Comm-B request, it knows that it is the reserved site for this message and that it should complete the transaction by closing out the message.*

2.2.19.2.3.2 Multisite Directed Comm-B Transmissions

If the airborne data system needs to direct a Comm-B message to a specific interrogator, the air-initiated Comm-B protocol **shall** be used together with the multisite protocol above. When the B-timer is not running, the IIS of the desired destination **shall** be stored and transmitted in bits 14-17, together with IDS=1 in bits 18 and 19 of the UM field unless UM use is preempted by command from the ground. Simultaneously the B-timer **shall** be started and code DR=1 transmitted.

The reservation **shall not** be automatically timed out by the transponder but **shall** continue until either:

a. the message is read and closed out by the reserved site; or

b. the message is canceled by the data link processor.

Note: *This protocol is intended to result in delivery of the message only to the reserved site. As in all air-initiated messages, the data link processor may withdraw the message if delivery has not been accomplished within a nominal time or if another air-initiated message is waiting to be sent. In this protocol the B-timer* *in the transponder is not actually used as a timer. However, it does retain its function as a flag to indicate that a multisite transaction is in progress (see §2.2.19.2.3.1).*

2.2.19.2.3.3 Multisite Comm-B Closeout

Multisite Comm-B closeout is accomplished using a surveillance or Comm-A interrogation containing:

Either:	DI	=	1 (multisite SD format).
	IIS	=	Interrogator site number.
	MBS	=	2 (Comm-B closeout).
Or:	DI	=	0, 1 or 7
	IIS	=	Interrogator site number
	PC	=	4 (Comm-B closeout)

If IIS of the interrogation equals the stored Comm-B IIS, the stored Comm-B **shall** be cleared, the B-timer stopped, the DR code 1 for this message reset and the message itself canceled. If the site numbers do not match, the message **shall not** be canceled and the stored Comm-B IIS, B-timer and DR code **shall** remain unchanged. The transponder **shall not** close out a multisite air-initiated Comm-B message unless it has been read out at least once by the reserved site.

2.2.19.2.3.4 Automatic Comm-B Closeout

If the transponder B-timer runs out before a multisite closeout is accepted, the stored Comm-B IIS **shall** be set to ZERO (0), and the T-register **shall** be cleared to enable this message to be read and cleared by another site.

2.2.19.2.3.5 Significance of PC Command

When the transponder is in the multisite mode, i.e., when the IIS stored for Comm-B is not ZERO (0), receipt of a closeout (PC=4) **shall** have no effect on the transaction unless accompanied by IIS equal to the stored Comm-B IIS.

2.2.19.3 Additional Features

Additional features are refinements or extensions of the transponder design which may be required for transponders used in special circumstances or missions.

2.2.19.3.1 Diversity

Diversity, as specified in §2.2.12, should be implemented in wide-body aircraft and in conjunction with transponders installed with airborne collision avoidance systems (CAS).

2.2.19.3.2 Mutual Suppression System

Mutual suppression systems may be needed if the aircraft has other pulse L-band equipment on board or if the transponder is used in conjunction with certain CAS (see §2.2.11).

2.2.20 Level 3 & Level 4 Transponder – Extended Length Message (ELM) Protocols

2.2.20.1 Level 3 Uplink ELM

2.2.20.1.1 Uplink ELM Capability

This additional capability described in §1.4.3.3 requires that the transponder **shall**, in addition to the functions of the Level 2 transponder:

a. Process uplink and downlink formats UF=DF=24.
b. Follow the protocols for Comm-C.
c. Follow the applicable procedures for multisite operation.

Note: *This transponder uses all the formats shown in Figure 2-5 and Figure 2-6.*

2.2.20.1.1.1 Comm-C/ELM Protocol (Figure 2-21 and Figure 2-22)

Uplink ELMs are transmitted in segments with each segment formed by a Comm-C format.

In addition to the segment content in MC, two protocol fields, NC and RC, are used. NC is the segment number transmitted.

RC identifies the transmission as initial, intermediate or final.

The minimum length of an uplink ELM is two segments. The transfer of all segments may take place without intervening replies. The minimum time between the beginning of successive Comm-C transmissions is 50 microseconds.

2.2.20.1.1.1.1 Initializing Segment Transfer

The ELM transaction for an n-segment message (NCs 0 through n-l) **shall** be initiated upon receipt of a Comm-C transmission containing RC=0. The text transmitted in MC **shall** be stored. This text is the last segment of the message and carries NC=n-l. Upon receipt of NC, the transponder **shall** establish the number of further segments to be received and stored. Receipt of an initializing (RC=0) segment **shall** establish the "setup" in the transponder, which is now prepared to accept further segments.

Receipt of another initializing segment **shall** result in a new setup within the transponder and cause any previously stored segments to be discarded.

A transponder reply **shall not** be generated on receipt of an initializing segment.

2.2.20.1.1.1.2 Intermediate Segment Transfer

Intermediate segments are characterized by RC=1 and **shall** be accepted and stored by the transponder only if the setup of the previous paragraph is in effect and if the received NC is smaller than the value stored at receipt of the initializing segment.

A reply **shall not** be generated on receipt of the intermediate segment.

Note: *Intermediate segments may be transmitted in any order.*

2.2.20.1.1.1.3 Final Segment Transfer

The final segment, characterized by RC=2, **shall** be accepted by the transponder under all circumstances and requires a reply (with the standard 128-microsecond Mode S reply delay). The segment content **shall** be stored if the setup of §2.2.20.1.1.1.1 is in effect and if the received NC is smaller than the value of the initial segment NC.

2.2.20.1.1.1.4 Completed Message

The message is completed if all segments announced by NC in the initializing segment have been received. If the message is completed, the content **shall** be transferred to the ELM interface of §2.2.13.4, and the setup **shall** be deactivated.

2.2.20.1.1.1.5 Acknowledgment Reply

The transponder **shall** acknowledge receipt of a final segment by replying with a Comm-D transmission, with KE=1. KE=1 indicates that the MD field contains subfield TAS that reports which segments have been received. This reply **shall** be transmitted 128 microseconds plus or minus 0.25 microsecond following receipt of the sync phase reversal of the interrogation delivering the final segment.

The information contained in the TAS subfield **shall** be continually updated while segments are received and **shall not** be cleared until a new initializing segment is received or until closeout occurs.

Note: *Segments lost in uplink transmission are noted by their absence in the TAS report and are re-transmitted by the interrogator, which will then send further final segments to assess the situation.*

2.2.20.1.1.1.6 TAS Transmission Acknowledgment, Subfield in MD

This 16-bit (bits 17 – 32) downlink subfield in MD **shall** report the segments received so far in a Comm-C sequence. Starting with bit 17, which denotes segment number "0," each of the following bits is ONE if the corresponding segment of the sequence has been received. TAS appears in MD if KE=1 in the same reply.

2.2.20.1.1.1.7 Closeout

A closeout transmission informs the transponder that the TAS has been received and that it **shall** be cleared. This closeout (PC=5) is contained in a surveillance or Comm-A interrogation.

An uncompleted message, present when the closeout is received, **shall** be closed out.

2.2.20.1.1.1.8 Information Transfer

Comm-C equipped transponders **shall** be able to transfer received information to the appropriate data sinks (see §2.2.13, §2.2.19.b and §2.2.19.c).

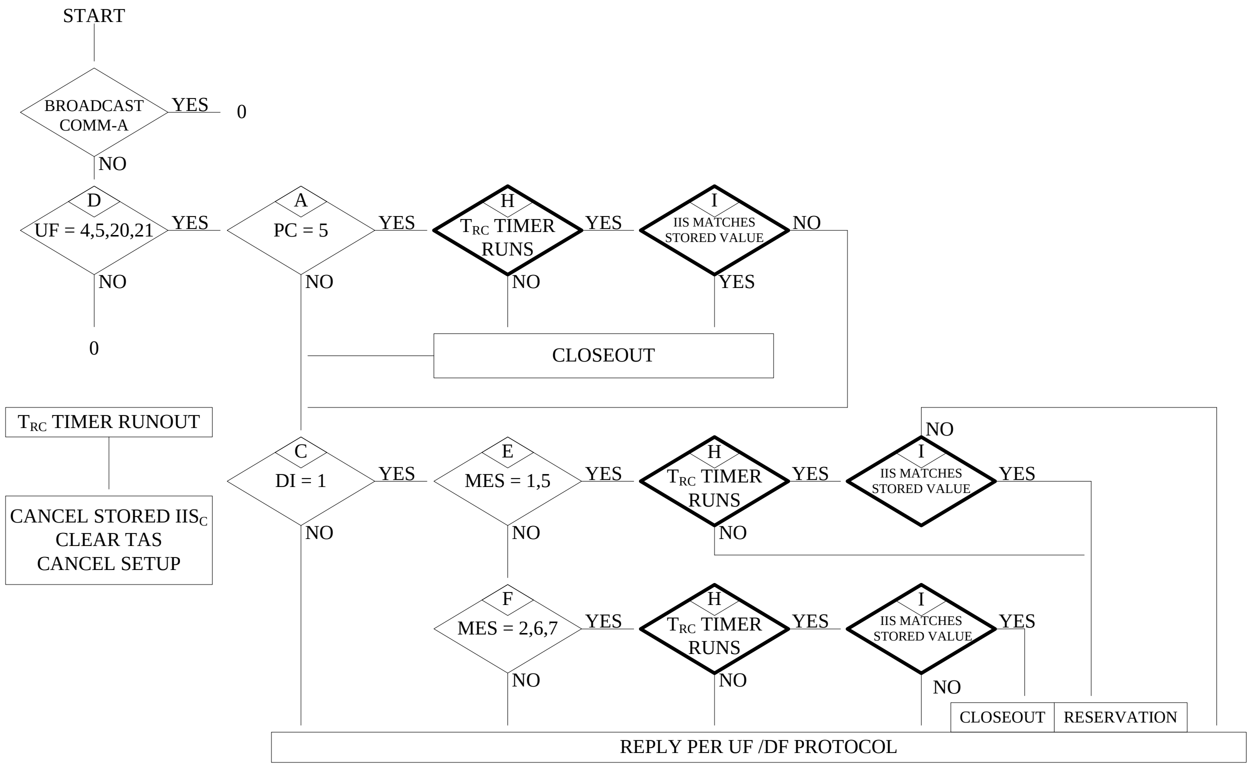
2.2.20.1.2 Uplink Interface – Interrogator Identity

In addition to data transferred per §2.2.20.1.4, the uplink interface signal **shall** contain the interrogator site number (IIS) of the sensor that has transmitted an ELM by multisite protocol. The IIS stored for Comm-C (see §2.2.20.1.3.1) when the message is completed (see §2.2.20.1.1.1.4) **shall** be used for this purpose.

Note: *If the multisite protocol is not used, an IIS code of ZERO will be stored and reported.*

2.2.20.1.3 Multisite Uplink ELM Protocol (Figure 2-21 and Figure 2-22)

Note: *The multisite Comm-C protocol augments the standard Comm-C protocol and when not in use does not modify the standard protocol in any way. Codes used in the SD and UM fields for ELM multisite protocols are described in §2.2.19.2.1.1 and §2.2.19.2.1.2.*



<u>Figure 2-21:</u> Comm-C Reservation and Closeout

<u>Notes:</u>

1. *"Reservation" indicates that the IIS is stored and the Timer is started.*
2. *"Closeout" indicates that the stored IIS is cancelled, the Timer is stopped, TAS is cleared and the setup is cancelled.*
3. *"0" indicates termination of the process.*
4. *Bold boxes indicate Transponder States.*
5. *This Figure does not include the Enhanced Data Link Protocol features.*

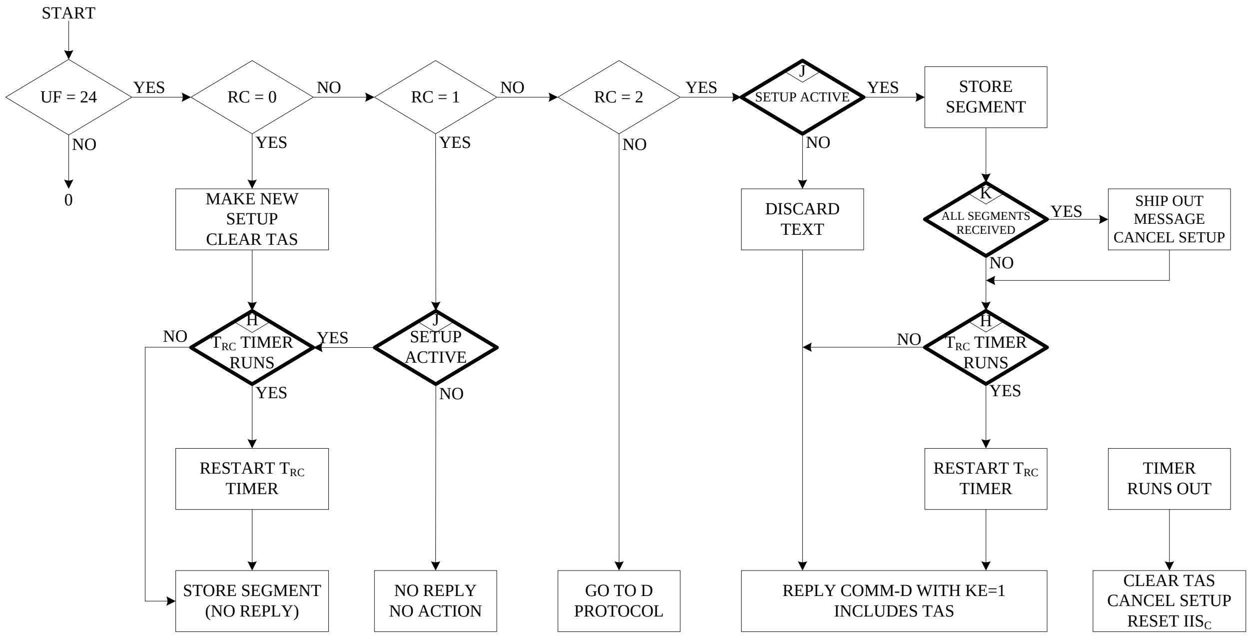


Figure 2-22: Comm-C Message Handling

Notes:

1. *Bold boxes indicate Transponder States.*
2. *"0" indicates termination of process.*
3. *This Figure does not include the Enhanced Data Link Protocol features.*

2.2.20.1.3.1 Multisite Comm-C Reservations

When the multisite protocol is in use, an interrogator makes a reservation for an uplink ELM by transmitting a surveillance or Comm-A interrogation containing:

DI	=	1 (multisite SD format).
IIS	=	Interrogator's site number.
MES	=	1 or 5 (Comm-C reservation request).

The interrogator may also transmit:

RSS	=	2 (Comm-C reservation status request).

Protocol procedure in response to this interrogation **shall** depend upon the state of the C-timer as follows:

a. C-timer not running

   Store IIS for Comm-C.
   Start C-timer.

b. C-timer running and interrogator's IIS equals stored Comm-C IIS

   Restart C-timer.

c. C-timer running and interrogator's IIS is not equal to stored Comm-C IIS

No change to stored IIS or C-timer.

Note: *When an interrogator asks for Comm-C reservation status and receives its own site number in the UM field of the reply to a reservation interrogation, it proceeds with the delivery of the uplink ELM. Otherwise, ELM activity is not started during this ground antenna scan and a new reservation request is made during the next scan.*

2.2.20.1.3.2 Multisite Comm-C Delivery

After multisite coordination is accomplished via the surveillance or Comm-A interrogation, uplink ELM delivery **shall** be as described in §2.2.20.1.1. In addition, the C-timer **shall** be restarted each time a received segment is stored and the stored Comm-C IIS is not ZERO (0).

Note: *The requirement that the stored Comm-C IIS be other than "0" prevents the C-timer from being restarted during a non-selective uplink ELM transaction.*

2.2.20.1.3.3 Multisite Comm-C Closeout

Multisite Comm-C closeout **shall** be accomplished upon receipt of a surveillance or Comm-A interrogation containing:

DI	=	1 (Multisite SD format).
IIS	=	Interrogator's site number.
MES	=	2, 6 or 7 (Comm-C closeout).

If the stored Comm-C IIS equals the IIS of the interrogator, the uplink ELM **shall** be closed out as described in §2.2.20.1.1.1.7, the stored Comm-C IIS **shall** be cleared and the C-timer stopped. If the site numbers do not match, the message **shall not** be closed out and the states of the stored Comm-C IIS and the C-timer remain unchanged.

2.2.20.1.3.4 Automatic Comm-C Closeout

The closeout actions described in §2.2.20.1.3.3 **shall** be initiated automatically when the C-timer runs out.

2.2.20.1.3.5 Significance of PC Command

When the transponder is in the multisite mode, i.e., when the IIS stored for Comm-C is not ZERO (0), receipt of a cancellation (PC=5) **shall** have no effect on the transaction unless accompanied by IIS equal to the stored Comm-C IIS.

2.2.20.1.4 Uplink Interface – Data Rate

A transponder equipped for standard uplink ELM operation **shall** be able to transfer data from at least four complete 16-segment uplink ELMs in any four-second period. A transponder equipped for enhanced uplink ELM operation **shall** be able to transfer data from at least four 16-segment uplink ELMs in any one-second period. In each case, the ELMs **shall** be transferred if they are spaced no closer than 5 milliseconds from the end of one ELM to the beginning of the next. For transponders equipped with the enhanced protocols, this 5 millisecond spacing requirement **shall** also apply to successive 16 segment ELMs bearing the same II code. The content of any uplink ELM **shall** be available for transfer across the output interface no later than ONE (1) second after it has been received.

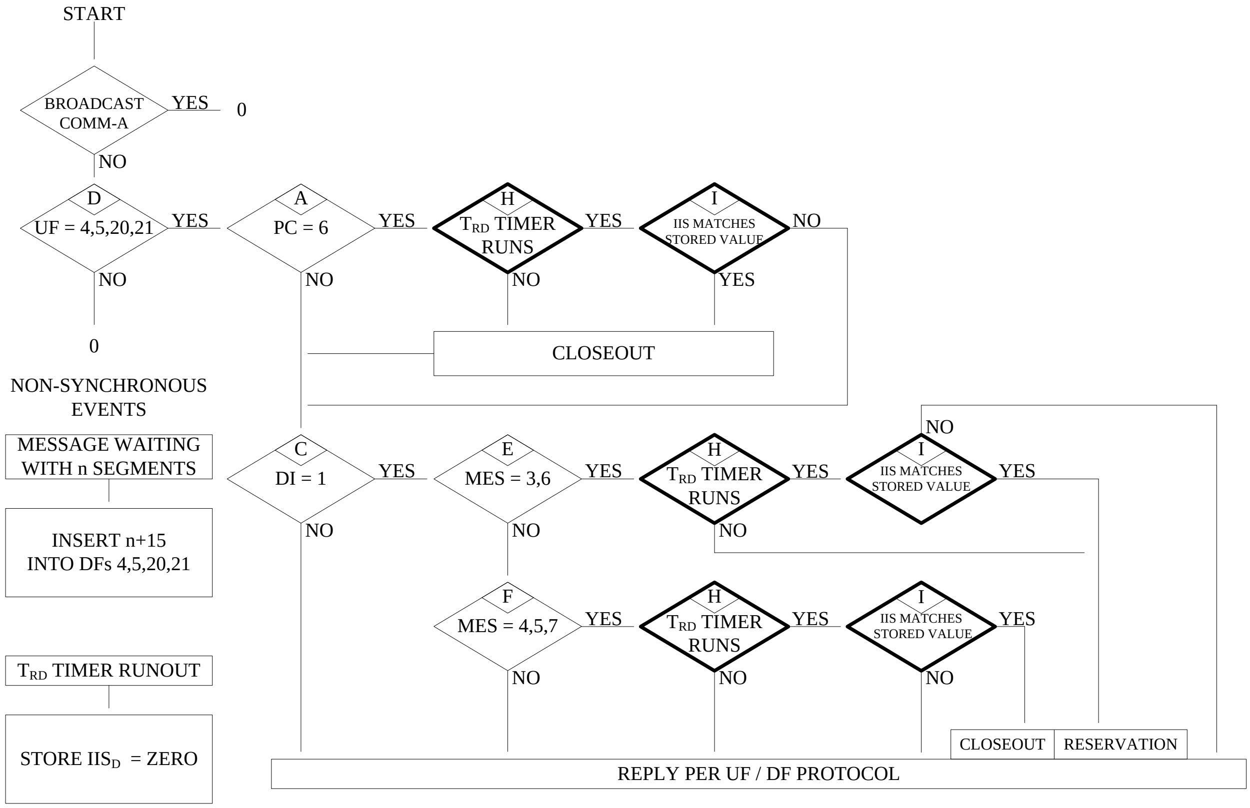
Note: *This requirement allows the transponder to operate in regions in which there are multiple interrogators operating in the multi-site or enhanced protocol mode. It also permits the transponder to take advantage of the capabilities of a sensor with an electronically-scanned antenna*

2.2.20.2 Level 4 Downlink ELM

2.2.20.2.1 Full ELM Capability (Figure 2-23 and Figure 2-24)

This additional capability, described in §1.4.3.4, requires that the transponder **shall**, in addition to the functions previously described, follow the protocols for:

a. Comm-D ELM.
b. Applicable multisite procedures.
c. Report Codes 4 through 7 in the CA field (see §2.2.14.4.6).



<u>Figure 2-23:</u> Comm-D Reservation and Closeout

<u>Notes:</u>

1. *"Reservation" indicates that the IIS is stored and the Timer is started.*
2. *"Closeout" indicates that the stored IIS is cancelled, the Timer is stopped, DR is cleared and the setup is cancelled.*
3. *The D-Register (see Figure 2-24) indicates that a Command to transmit segments (SRS) has been received at least once.*
4. *"0" indicates termination of the process.*
5. *Bold boxes indicate Transponder States.*
6. *Closeout is only permitted if the D-Register is set.*
7. *The D-Register is reset when the D-Timer expires.*
8. *Additional processing for multisite-directed Comm-D transmissions is defined in §2.2.20.2.3.2.*
9. *This Figure does not include the Enhanced Data Link Protocol features.*

2.2.20.2.1.1 The Comm-D/ELM Protocol (Figure 2-24)

Downlink ELMs **shall** be transmitted only after authorization by the interrogator. The segments to be transmitted are contained in Comm-D replies.

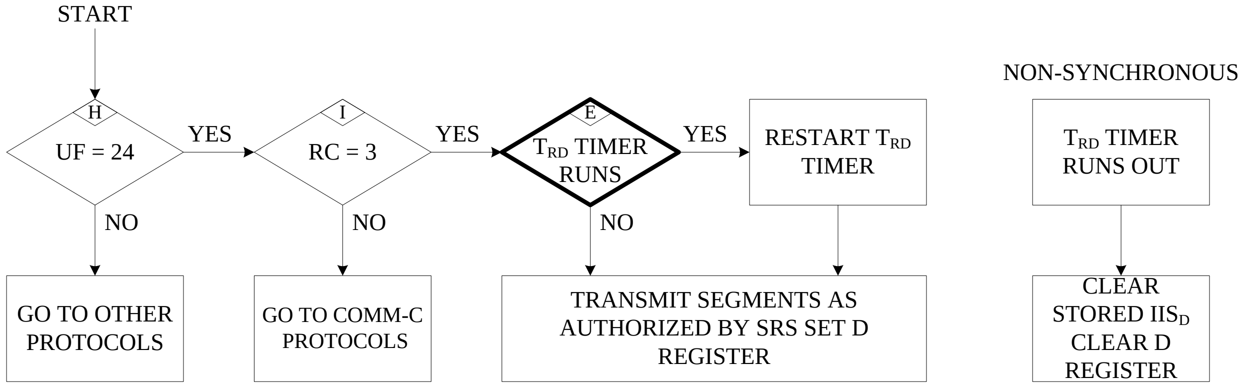


Figure 2-24: Comm-D Message Handling

Notes:

1. *Bold boxes indicate Transponder States.*
2. *Additional processing required for multisite-directed Comm-D transmissions is defined in §2.2.20.2.3.2.*
3. *This Figure does not include the Enhanced Data Link Protocol features.*

2.2.20.2.1.1.1 Initialization

To request permission to send n-segments, the transponder **shall** insert the code corresponding to the value 15+n into the DR field of a surveillance or Comm-B reply, DF=4, 5, 20, 21.

2.2.20.2.1.1.2 Authorization and Transmission

The interrogator requests the transmission of Comm-D segments by a Comm-C interrogation characterized by RC=3. This Comm-C format carries the SRS subfield which is a summary of the segments to be transmitted. On receipt of this authorization the transponder **shall** transmit the first segment with the standard 128-microsecond Mode S reply delay followed by subsequent segments at a rate of one every 136 ±1 microseconds by means of Comm-D formats with KE=0 and ND corresponding to the number of the segment in MD. Segments can be transmitted in any order. The authorization process may be repeated by the interrogator.

2.2.20.2.1.1.3 SRS Segment Request Subfield in MC

If a Comm-C interrogation (UF=24) contains RC=3, it also contains a list of segment request-authorizations in the 16-bit (bits 9 – 24) SRS subfield. Starting with bit 9, which denotes the first segment, each of the following bits is set to ONE if the transmission of the corresponding segment is requested.

2.2.20.2.1.1.4 Closeout

A closeout transmission is used to inform the transponder that all segments have been received and that the DR field **shall** be reset. This closeout (PC=6) is contained in a surveillance or Comm-A interrogation and **shall** be effective only after a request for transmission has been complied with at least once (see D-Register in Figure 2-23 and Figure 2-24).

2.2.20.2.1.1.5 Information Transfer

The Comm-D/ELM-equipped transponder **shall** have access to the appropriate data sources (see §2.2.13.4, §2.2.19.b and §2.2.19.c).

2.2.20.2.2 Downlink Message Cancellation

Downlink interfaces of storage design for both Comm-B and ELM **shall**, in addition to data transfer, accept a signal that cancels a message previously transferred into the transponder if the delivery cycle of the message has not been closed out by ground command.

If more than one message is stored within the transponder for future transmission, the cancellation procedure **shall** be capable of canceling the stored messages selectively.

2.2.20.2.3 Multisite Downlink ELM Protocol

Note: *The multisite Comm-D protocol augments the standard Comm-D protocol and when not in use does not modify the standard protocol in any way. Codes used in the SD and UM fields for ELM multisite protocols are described in §2.2.19.2.1.1 and §2.2.19.2.1.2.*

2.2.20.2.3.1 Multisite Comm-D Reservation

When the multisite protocol is in use, an interrogator makes a reservation for ground initiation of a Comm-D message transfer by transmitting a surveillance or Comm-A interrogation containing:

DI	=	1 (multisite SD format).
IIS	=	Interrogator's site number.
MES	=	3 or 6 (Comm-D reservation request).

The interrogator may also transmit:

RSS	=	3 (Comm-D reservation status request).

A multisite downlink ELM reservation **shall not** be granted by the transponder unless a downlink ELM is waiting to be transmitted.

Protocol procedure in response to this interrogation **shall** depend upon the state of the D-timer as follows:

a. D-timer not running

   Store IIS for Comm-D.
   Start D-timer.

b. D-timer running and interrogator's IIS equals stored Comm-D IIS

   Restart D-timer.

c. D-timer running and interrogator's IIS is not equal to stored Comm-D IIS

   No change to stored IIS or D-timer.

Note: *When an interrogator asks for Comm-D reservation status and receives its own site number in the UM field of the reply to a reservation interrogation, it proceeds to request delivery of the downlink ELM. Otherwise, ELM activity is not started during this ground antenna scan and a new reservation request may be made during the next scan.*

2.2.20.2.3.2 Multisite Directed Comm-D Transmissions

If the airborne data system needs to direct a Comm-D ELM message to a specific interrogator, a procedure corresponding to the directed Comm-B protocol **shall** be used.

In effect, a "self reservation" is accomplished by storing the IIS of the desired site destination and proceeding with the usual protocol. The stored IIS and IDS=3 **shall** be transmitted in the UM field unless UM use is preempted by command from the ground or there is a Comm-B reservation.

For a multisite directed Comm-D message, the reservation **shall not** be automatically timed out but **shall** continue until either:

a. the message is read and closed out by the reserved site; or

b. the message is canceled by the data link processor.

Note: *This protocol is intended to result in delivery of the message only to the reserved site. As in all downlink ELM messages, the data link processor may withdraw the message if delivery has not been accomplished within a nominal time or if another message is waiting to be sent. In this protocol the D-timer in the transponder is not actually used as a timer. However, it does retain its function as a flag to indicate that a multisite transaction is in progress (see §2.2.19.2.3.1).*

2.2.20.2.3.3 Multisite Comm-D Delivery

After multisite coordination is accomplished by the surveillance or Comm-A interrogation, downlink ELM delivery **shall** be as described in §2.2.20.2.1.1.

In addition, the D-timer **shall** be restarted each time a request for Comm-D segments is received and the stored Comm-D IIS is other than "0."

Note: *The requirement that the stored Comm-D IIS be other than "0" prevents the D-timer from being restarted during a standard downlink ELM transaction.*

2.2.20.2.3.4 Multisite Comm-D Closeout

Multisite Comm-D closeout is accomplished using a surveillance or Comm-A interrogation containing:

DI	=	1 (Multisite SD format).
IIS	=	Interrogator's site number.
MES	=	4, 5, or 7 (Comm-D closeout).

If the stored Comm-D IIS equals the IIS of the interrogator, the downlink ELM **shall** be closed out as described in §2.2.20.2.1.1.4. The stored Comm-D IIS **shall** be cleared and the D-timer stopped. If the site numbers do not match, the message is not closed out and the states of the stored Comm-D IIS, the D-timer and the DR code remain unchanged.

2.2.20.2.3.5 Automatic Comm-D Closeout

If the D-timer runs out, the stored Comm-D IIS **shall** be set to "0." The Comm-D message and the DR field **shall not** be cleared. (This makes it possible for another site to read and clear the Comm-D message.)

2.2.20.2.3.6 Significance of PC Command

When the transponder is in the multisite mode, i.e., when the IIS stored for Comm-D is not ZERO (0), receipt of a closeout (PC=6) **shall** have no effect on the transaction unless accompanied by IIS equal to the stored Comm-D IIS.

2.2.20.2.4 Downlink Interface – Data Rate

A transponder equipped for standard downlink ELM operation **shall** be able to transmit at least four downlink ELM segments in any ONE (1)-second period. A transponder equipped for enhanced ELM operation **shall** be able to transmit at least sixteen downlink ELM segments in any ONE (1)-second period.

2.2.21 Level 5 Transponder – Enhanced Protocols

2.2.21.1 Enhanced Air-Initiated Comm-B Protocol

Note: *The enhanced air-initiated Comm-B protocol provides a higher data link capacity by permitting parallel delivery of air-initiated Comm-B messages by up to 16 interrogators, one for each II code. Operation without the need for multisite Comm-B reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced air-initiated Comm-B protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.*

2.2.21.1.1 General

The interrogator **shall** determine from the data link capability report whether the transponder supports the enhanced protocols. If the enhanced protocols are supported, Comm-B messages delivered using the multisite protocol may be delivered without a prior reservation. If the enhanced protocols are not supported by both the interrogator and the transponder, the multisite reservation protocols specified in §2.2.19.2.3.1 **shall** be used.

Recommendation: *If the transponder and the interrogator are equipped for the enhanced protocol, the interrogator should use the enhanced Comm-B protocol.*

The transponder **shall** be capable of storing 2 or more messages for each of the 16 II codes: (1) an air-initiated or multisite-directed Comm-B message and (2) the contents of registers for BDS1=0 and BDS2=2 through 4.

Note: *GICB Registers 02_{16} – 04_{16} are used for the Comm-B linking protocol defined in Appendix B.*

2.2.21.1.2 Enhanced Multisite Air-Initiated Comm-B Protocol

2.2.21.1.2.1 Initiation

An air-initiated Comm-B message input into the transponder **shall** be stored in the registers assigned to II=0.

2.2.21.1.2.2 Announcement and Extraction

A waiting air-initiated Comm-B message **shall** be announced in the DR field of the replies to all interrogators for which a multisite directed Comm-B message is not waiting. The UM field of the announcement reply **shall** indicate that the message is not reserved for any II code, i.e., the IIS subfield **shall** be set equal to ZERO. When a command to read this message is received from a given interrogator, the B Timer for the associated interrogator is started and the reply containing the message **shall** contain the same IIS subfield content indicating that the message is reserved for the II code contained in the interrogation from that interrogator. After readout and until closeout, the message **shall** continue to be assigned to that II code. Once a message is assigned to a specific II code, announcement of this message **shall** be no longer made in the replies to interrogators with other II codes. If the message is not closed out by the assigned interrogator for the period of the B-timer, the message **shall** revert back to multisite air-initiated status and the process **shall** repeat. Only one multisite air-initiated Comm-B message **shall** be in process at a time.

2.2.21.1.2.3 Closeout

A closeout for a multisite air-initiated message **shall** only be accepted from the interrogator that is currently assigned to transfer the message.

2.2.21.1.2.4 Announcement of the Next Message Waiting

The DR field **shall** indicate a message waiting in the reply to an interrogation containing a Comm-B closeout to an air-initiated message if an unassigned air-initiated message is waiting and has not been assigned to an II code, or if a multisite-directed message is waiting for that II code (see §2.2.21.1.3).

2.2.21.1.3 Enhanced Multisite Directed Comm-B Protocol

2.2.21.1.3.1 Initiation

When a multisite directed message is input into the transponder, it **shall** be placed in the Comm-B registers assigned to the II code specified for the message and starts the B-timer. If the registers for this II code are already occupied, (i.e., a multisite directed message is already in process to this II code) the new message **shall** be queued until the current transaction with that II code is closed out.

Note: *For a multisite-directed message, the B-timer does not expire. A multi-site directed message can only be canceled by the ADLP.*

2.2.21.1.3.2 Announcement

Announcement of a Comm-B message waiting transfer **shall** be made using the DR field as specified in §2.2.14.4.13 with the destination interrogator II code contained in the IIS subfield as specified in §2.2.19.2.1.1. The DR field and IIS subfield contents **shall** be set specifically for the interrogator that is to receive the reply. A waiting multisite directed message **shall** only be announced in the replies to the intended interrogator. It **shall not** be announced in the replies to other interrogators.

Notes:

1. *If a multisite-directed message is waiting for II=2, the surveillance replies to that interrogator will contain DR=1 and IIS=2. If this is the only message in process, replies to all other interrogators will indicate that no message is waiting.*
2. *In addition to permitting parallel operation, this form of announcement enables a greater degree of announcement of downlink ELMs. The announcements for the downlink ELM and the Comm-B share the DR field. Only one announcement can take place at a time because of coding limitations. In case both a Comm-B and a downlink ELM are waiting, announcement preference is given to the Comm-B. In the example above, if an air-directed Comm-B was waiting for II=2 and a multisite-directed downlink ELM was waiting for II=6, both interrogators would see their respective announcements on the first scan since there would be no Comm-B announcement to II=6 to block the announcement of the waiting downlink ELM.*

2.2.21.1.3.3 Closeout

Closeout **shall** be accomplished as specified in §2.2.19.2.3.3.

2.2.21.1.3.4 Announcement of the Next Message Waiting

The DR field **shall** indicate a message waiting in the reply to an interrogation containing a Comm-B closeout if another multisite directed message is waiting for that II code, or if an air-initiated message is waiting and has not been assigned to an II code (see §2.2.19.1.12.4).

2.2.21.1.4 Enhanced Broadcast Comm-B Protocol

A broadcast Comm-B message **shall** be announced to all 16 interrogator II codes. The message **shall** remain active for the period of the B-timer associated with each II code (i.e., the message **shall not** be withdrawn after a single B-timer timeout, but is intended to be read-out by each II code within view). The provision for interruption of a broadcast by non-broadcast Comm-B as specified in §2.2.19.1.12.5 **shall** apply separately to each II code. When the B-timer period has been achieved for all II codes, the broadcast message **shall** be automatically cleared as specified in §2.2.19.1.12.5. A new broadcast message **shall not** be initiated or announced until the current broadcast has been cleared.

Note: *Because of the fact that broadcast message interruption occurs independently for each II code, it is possible that the broadcast message timeout will occur at different times for different II codes.*

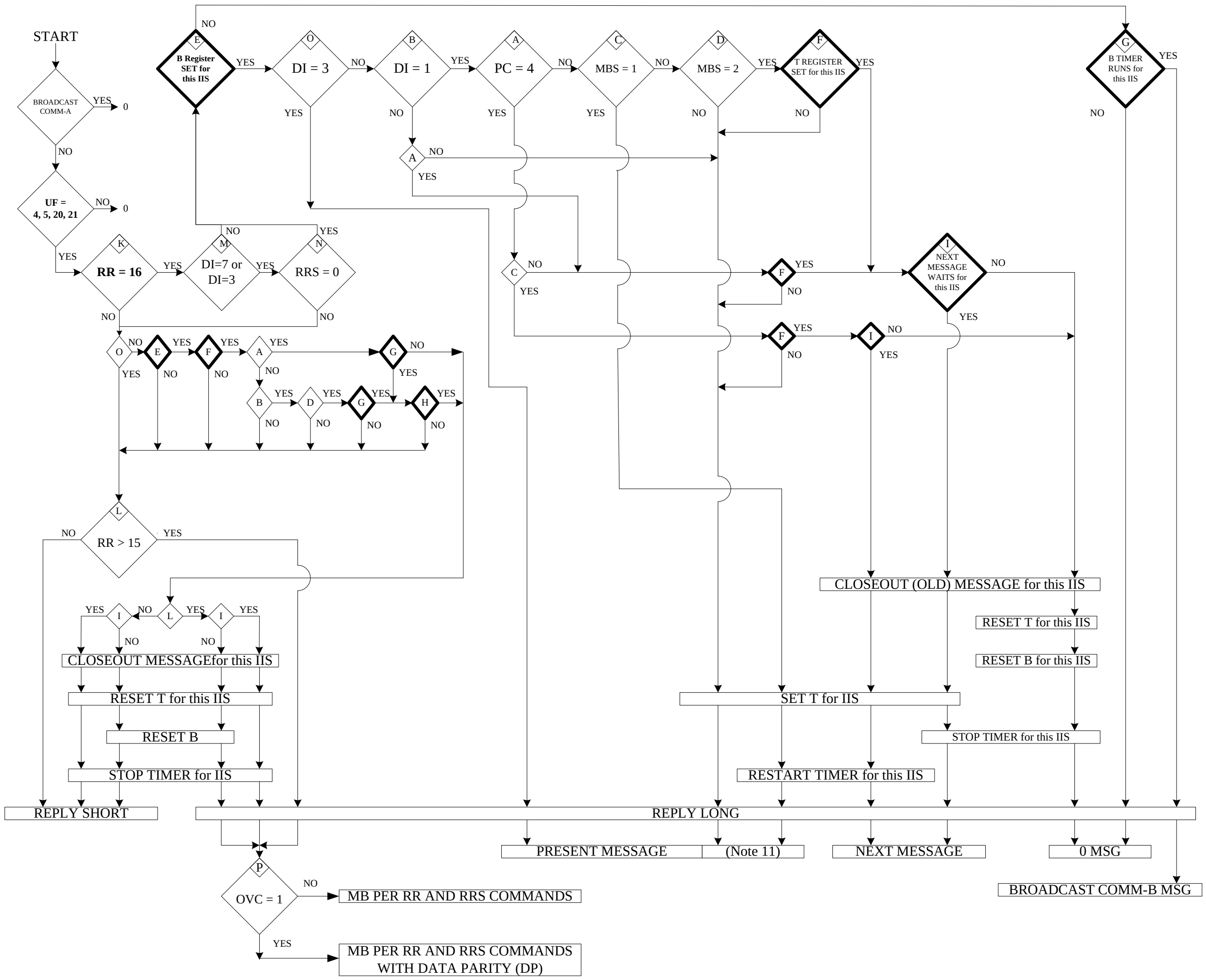
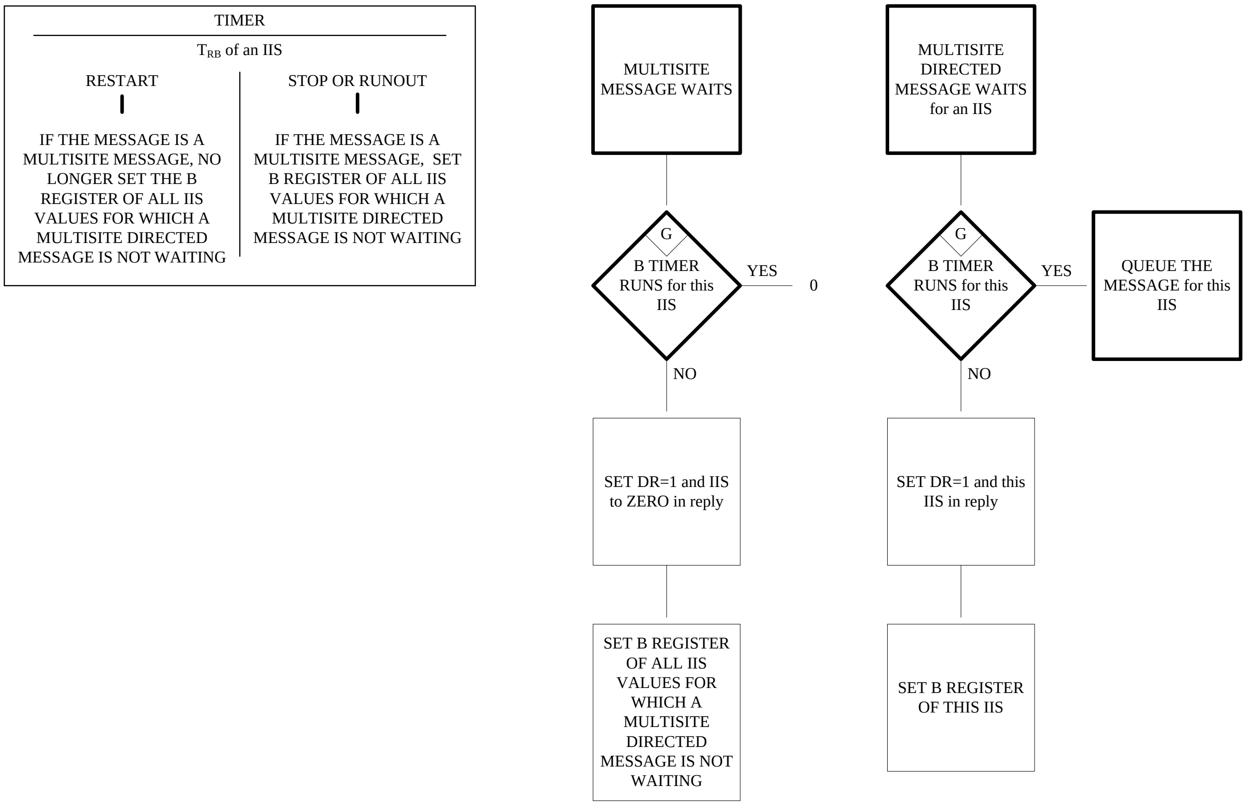


Figure 2-25: Enhanced Comm-B Protocol

Notes:

1. *Bold boxes indicate Transponder States.*
2. *"0" indicates termination of the process.*
3. *The T-Register (see Figure 2-24) indicates whether the message has been read at least once.*
4. *The PC field processing must be completed before any SD field processing.*
5. *The B-Timer does not expire for a multisite-directed Comm-B message.*
6. *Additional processing for multisite-directed Comm-B transmissions is defined in §2.2.19.2.3.2.*
7. *IIS is only defined if DI=0, 1 or 7.*
8. *The flowcharts of this figure should be run for all IIS values.*
9. *The B-Timer is started only if IIS≠0.*
10. *The T-Regster is reset when the B-Timer expires.*
11. *Additional instances of the same decision diamond are represented by a small diamond containing only the letter.*
12. *Set this IIS in reply if the UM field is not pre-empted by an interrogator command.*
13. *"B Register set for this IIS" means that either a multisite message or a multisite directed message is waiting for this IIS.*



<u>Figure 2-26:</u> Enhanced Comm-B Protocol – (Continued)

2.2.21.2 Enhanced Uplink ELM Protocol

<u>Note:</u> *The enhanced uplink ELM protocol provides a higher data link capacity by permitting parallel delivery of uplink ELM messages by up to sixteen interrogators, one for each II code. Operation without the need for multisite uplink ELM reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced uplink ELM protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.*

2.2.21.2.1 General

The interrogator **shall** determine from the data link capability report whether the transponder supports the enhanced protocols. If the enhanced protocols are supported, uplink ELMs delivered using the multisite protocol may be delivered without a prior reservation. If the enhanced protocols are not supported by both the interrogator and the transponder, the multisite reservation protocols specified in §2.2.20.1.3.1 **shall** be used.

<u>Recommendation:</u> *If the transponder and the interrogator are equipped for the enhanced protocol, the interrogator should use the enhanced uplink ELM protocol.*

The transponder **shall** be capable of storing a sixteen-segment message for each of the 16 II codes.

2.2.21.2.2 Reservation Processing

The transponder **shall** support reservation processing for each II code as specified in §2.2.20.1.3.1.

Notes:

1. *Reservation processing is required for interrogators that do not support the enhanced protocol.*
2. *Since the transponder can handle simultaneous uplink ELMs for all 16 II codes, a reservation will always be granted.*

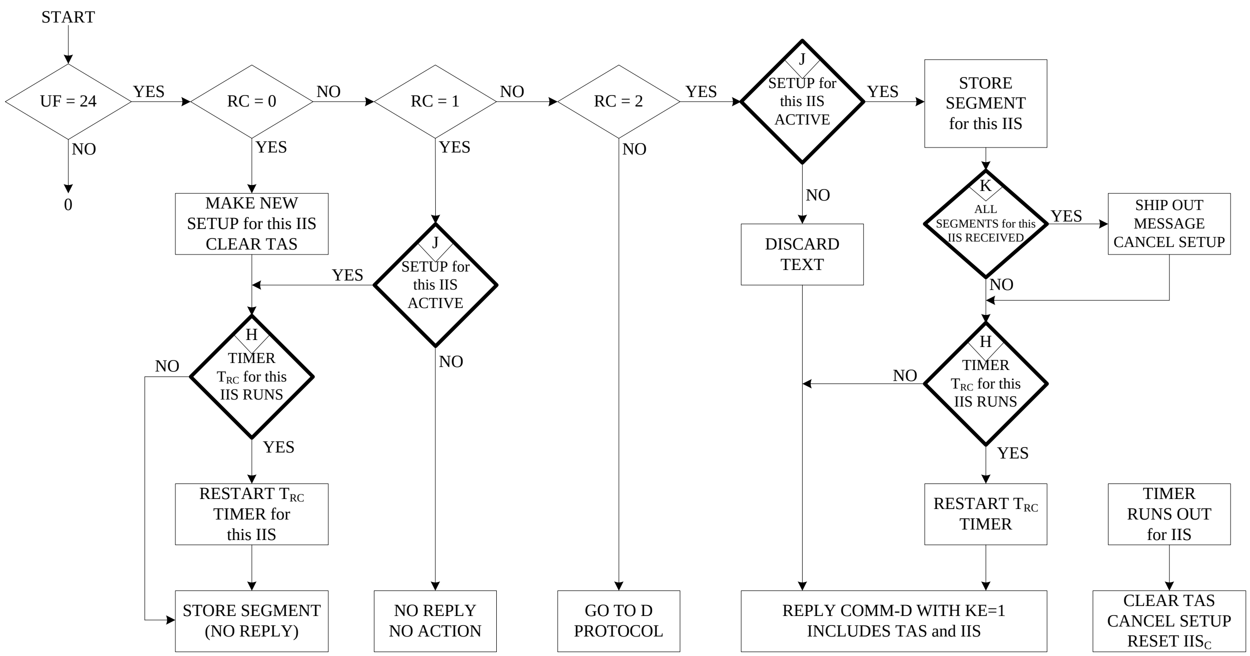


Figure 2-27: Enhanced Comm-C Reservation and Closeout

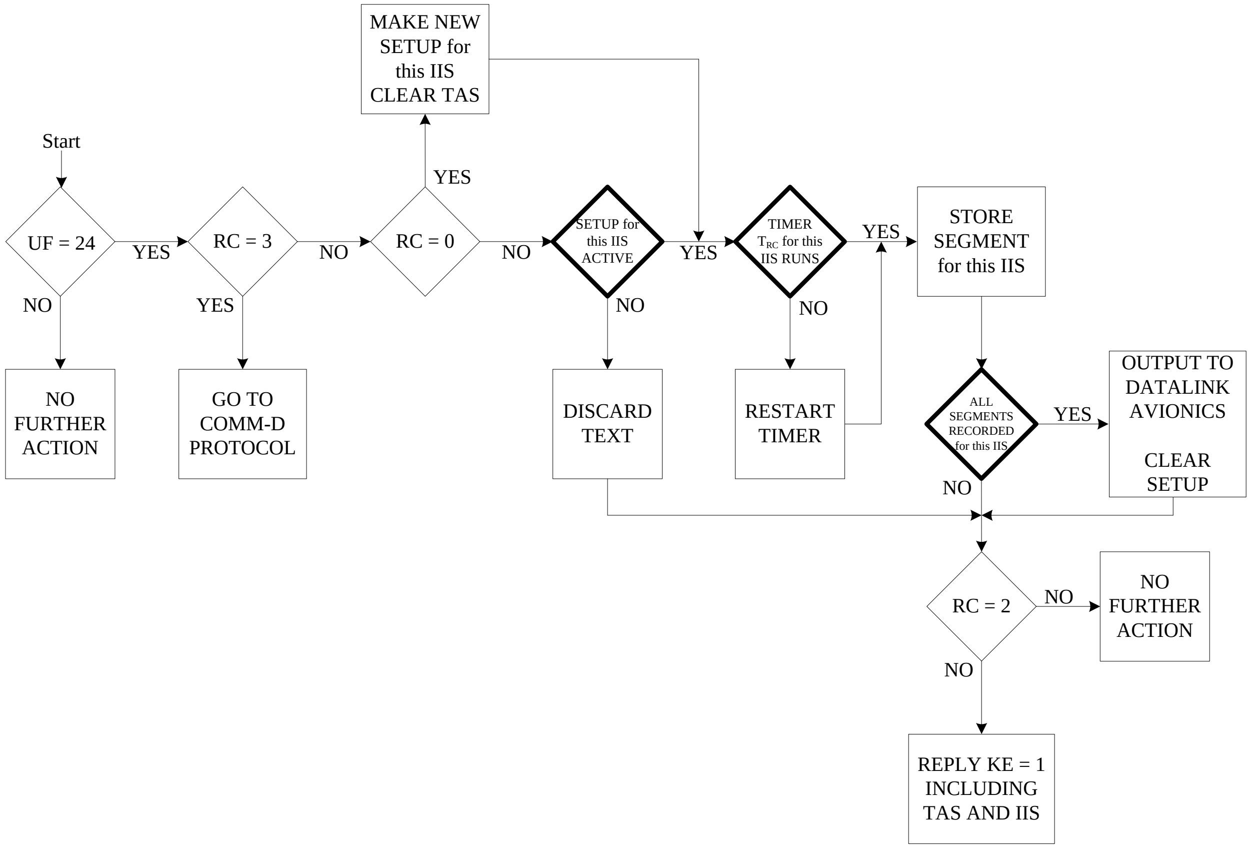
Notes:

1. *"Reservation" indicates that the Timer is started for this IIS.*
2. *"Closeout" indicates that the Timer is stopped and reset, TAS is cleared and the setup is cancelled for this IIS.*
3. *"0" indicates termination of the process.*
4. *Bold boxes indicate Transponder States.*
5. *If the timer for a particular IIS is running and a reservation is received for this IIS, this reservation will be granted. Since the timer is running, a former reservation has probably been received and will be cleared by this new reservation.*

2.2.21.2.3 Enhanced Uplink ELM Delivery and Closeout

The transponder **shall** process received segments separately by II code. For each value of II code, uplink ELM delivery and closeout **shall** be performed as specified in §2.2.20.1.3 and §2.2.20.1.1 except that the MD field used to transmit the technical acknowledgment **shall** also contain the 4-bit (bits 33 – 36) IIS subfield.

Note: *The interrogator may use the II code contained in the technical acknowledgment in order to verify that it has received the correct technical acknowledgment.*



<u>Figure 2-28:</u> Enhanced Comm-C Message Handling

<u>Notes:</u>

1. *Bold boxes indicate Transponder States.*
2. *Clear setup for an IIS does not clear TAS. TAS cleared by the receipt of a closeout message.*

2.2.21.3 Enhanced Downlink ELM Protocol

<u>Note:</u> *The enhanced downlink ELM protocol provides a higher data link capacity by permitting parallel delivery of downlink ELM messages by up to sixteen interrogators, one for each II code. Operation without the need for multisite downlink ELM reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced downlink ELM protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.*

2.2.21.3.1 General

The interrogator **shall** determine from the data link capability report whether the transponder supports the enhanced protocols. If the enhanced protocols are supported, downlink ELMs delivered using the multisite-directed protocol may be delivered without a prior reservation. If the enhanced protocols are not supported by both the interrogator and the transponder, the multisite reservation protocols specified in §2.2.20.2.3.1 **shall** be used for multisite and multisite-directed downlink ELMs.

Recommendation: *If the transponder and the interrogator are equipped for the enhanced protocol, the interrogator should use the enhanced downlink ELM protocol.*

The transponder **shall** be capable of storing a sixteen-segment message for each of the 16 II codes.

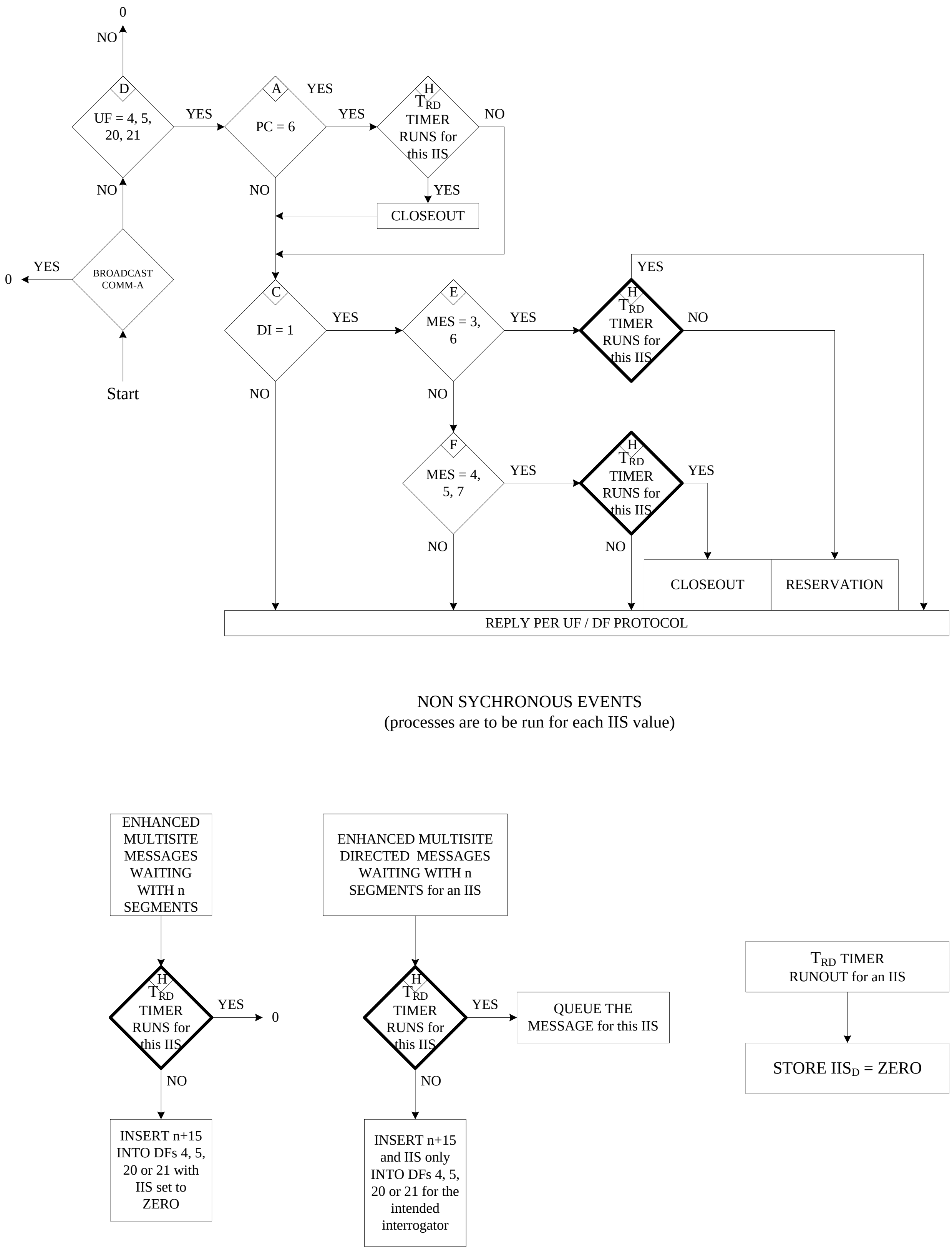
2.2.21.3.2 Enhanced Multisite Downlink ELM Protocol

2.2.21.3.2.1 Initiation

A multisite message input into the transponder **shall** be stored in the registers assigned to II=0.

2.2.21.3.2.2 Announcement and Extraction

A waiting multisite downlink ELM message **shall** be announced in the DR field of the replies to all interrogators for which a multisite directed downlink ELM message is not waiting. The UM field of the announcement reply **shall** indicate that the message is not reserved for any II code, i.e., the IIS subfield **shall** be set equal to ZERO. When a command to read out this message is received from a given interrogator, the message **shall** be reserved for the II code contained in the interrogation from that interrogator. After readout and until closeout, the message **shall** continue to be assigned to that II code. Once a message is assigned to a specific II code, announcement of this message **shall** no longer be made in the replies to interrogators with other II codes. If the message is not closed out by the associated interrogator for the period of the D-timer, the message **shall** revert back to multisite status and the process **shall** repeat. Only one multisite downlink ELM message **shall** be in process at a time.



<u>Figure 2-29:</u> Enhanced Comm-D Reservation and Closeout

Notes for Figure 2-29:

1. *"Reservation" indicates that the Timer is started for this IIS.*
2. *"Closeout" indicates that the Timer is stopped and reset, DR is cleared and the message is cancelled for this IIS.*
3. *The D-Register indicates is a message readout has Been attempted at least once for this IIS.*
4. *"0" indicates termination of the process.*
5. *Bold boxes indicate Transponder States.*
6. *Closeout is only permitted if the D-Register is set for this IIS.*
7. *The D-Register is reset when the D-Timer expires for this IIS.*
8. *Additional processing for multisite-directed Comm-D transmissions is defined in §2.2.20.2.3.2.*

2.2.21.3.2.3 Closeout

A closeout for a multisite message **shall** only be accepted from the interrogator that was assigned most recently to transfer the message.

2.2.21.3.2.4 Announcement of the Next Message Waiting

The DR field **shall** indicate a message waiting in the reply to an interrogation containing a downlink ELM closeout if an unassigned multisite downlink ELM is waiting, or if a multisite directed message is waiting for that II code.

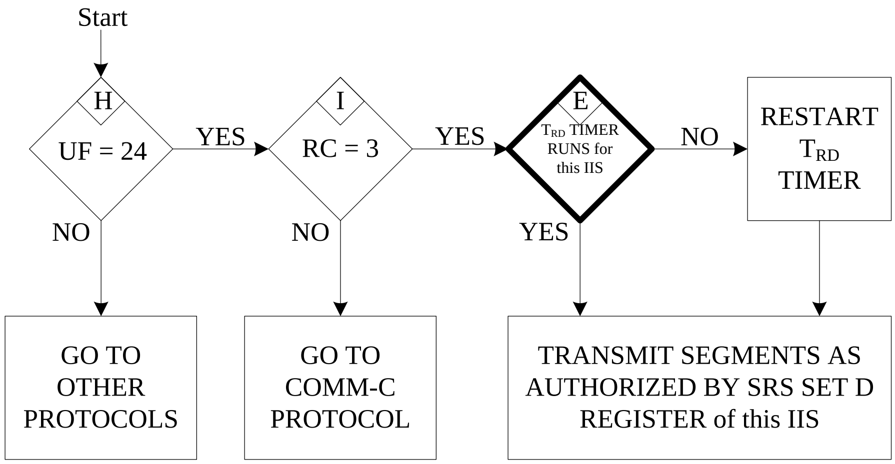


Figure 2-30: Enhanced Comm-D Message Handling

2.2.21.3.3 Enhanced Multisite Directed Downlink ELM Protocol

2.2.21.3.3.1 Initiation

When a multisite directed message is input into the transponder, it **shall** be placed in the downlink ELM registers assigned to the II code specified for the message. If the registers for this II code are already in use (i.e., a multisite directed downlink ELM message is already in process for this II code) the new message **shall** be queued until the current transaction with that II code is closed out.

2.2.21.3.3.2 Announcement

Announcement of a downlink ELM message waiting transfer **shall** be made using the DR field as specified in §2.2.20.2.1.1.1 with the destination interrogator II code contained in the IIS subfield as specified in §2.2.20.2.3.2. The DR field and IIS subfield contents **shall** be set specifically for the interrogator that is to receive the reply. A waiting multisite directed message **shall** only be announced in the replies to the intended interrogator. It **shall not** be announced in replies to other interrogators.

2.2.21.3.3.3 Delivery

An interrogator **shall** determine if it is the reserved site through coding in the UM field and, if so, it may proceed to request delivery of the downlink ELM. The delivery **shall** be performed as specified in §2.2.20.2.1.1.2. The transponder **shall** transmit the message contained in the buffer associated with the II code specified in the IIS subfield of the segment request interrogation.

2.2.21.3.3.4 Closeout

Closeout **shall** be accomplished as specified in §2.2.20.2.3.4 except that a message closeout **shall** only be accepted from the interrogator with an II code equal to the one that transferred the message.

2.2.21.3.3.5 Announcement of the Next Message Waiting

The DR field **shall** indicate a message waiting in the reply to an interrogation containing a downlink ELM close-out if another multisite directed message is waiting for that II code, or if a downlink message is waiting that has not been assigned an II code.

2.2.21.3.4 Enhanced Non-selective Downlink ELM Protocol

The availability of a non-selective downlink ELM message **shall** be announced to all interrogators. Otherwise, the protocol **shall** be as specified in §2.2.20.2.1.1.

2.2.22 TCAS-Compatible Mode S Transponder

There are various versions of TCAS systems with which Mode S Transponders may interface as per Table 2-3.

Table 2-3: TCAS Versions and Compatible Systems

TCAS Version	FAA TSO	RTCA MOPS
6.04A (“pre change 7”)	TSO-C119a	DO-185
7.0 (“change 7”)	TSO-C119b	DO-185A
7.1	TSO-C119c (pending)	DO-185B

In addition to the Level 2 Transponder capabilities defined in §2.2.19.1, the Mode S transponder used in conjunction with TCAS **shall** have the following capabilities:

a. Ability to handle the following formats:

Format Number	**Format Name**
UF=16	Long Special Surveillance Interrogation
DF=16	Long Special Surveillance Reply

b. Ability to receive long Mode S interrogations (UF=16) and generate long Mode S replies (DF=16) at a continuous rate of 60 per second.

   Note: *Although item "b" above states the minimum requirement, in certain high density traffic situations, the transponder could receive "bursts" of UF=16 interrogations at a much higher rate. The theoretical upper limit for a burst is 120 UF=16 interrogations received in a 100-millisecond interval, with no more than 10 unique UF=16 interrogations in any 1-second interval and no more than 120 total UF=16 interrogations in any 1-second interval.*

c. Means for delivering the TCAS data content of all accepted interrogations addressed to the TCAS equipment.

d. Antenna diversity (see §2.2.12).

e. Mutual suppression capability

f. RF performance compatibility with own aircraft's TCAS. Specifically, when the Mode S transponder transmitter is in the inactive state, the RF power at 1090 ±3 MHz at the terminals of the Mode S transponder antenna **shall not** exceed -70 dBm.

   Note: *This unwanted power restriction is necessary to insure that the Mode S transponder does not prevent TCAS from meeting its requirements. It assumes that the isolation between the transponder antenna and the TCAS antenna exceeds 20 dB. The resultant interference level at the TCAS RF port will then be below -90 dBm.*

g. Reply rate limiting for Mode S replies. The reply rate limiting device **shall** protect the transponder from over-interrogation while permitting at least the reply rates required in §2.2.13.3.1.c and §2.2.22.b above.

h. The ability to interface with both FAA TSO-C119a (for compatibility with RTCA/DO-185) and RTCA/DO-185A/B compatible units.

   An RTCA/DO-185A/B compatible transponder **shall** annunciate its capability to the on-board TCAS via the transponder/TCAS interface. Likewise, an RTCA/DO-185A/B compatible TCAS annunciates its capability to the on-board transponder via the transponder/TCAS interface. The capability of the transponder/TCAS system is then limited to the capability of either the transponder or the TCAS unit having the least capability.

   The transponder **shall** consider the transponder/TCAS system to be compatible with RTCA/DO-185A/B if and only if both the TCAS and the transponder are compatible with RTCA/DO-185A.

2.2.22.1 Message Fields and Protocols

2.2.22.1.1 MA Message, Comm-A Used by TCAS

Note: *Control of the TCAS sensitivity level can be accomplished by one or more ground-based Mode S sensors through the transmission of Comm-A interrogations, UF=20 or 21, containing TCAS Sensitivity Level Command Messages to the TCAS aircraft. The interrogator identification information required to correlate the sensitivity level command with a particular originating ground-based Mode S sensor site is contained in the IIS subfield (see §2.2.19.2.1.1) of SD of the same Comm-A.*

Subfields in MA for a TCAS Sensitivity Level Command Message

ADS: A-Definition Subfield – This 8-bit (bits 33 – 40) uplink subfield in MA defines the data contained in the remainder of MA. For convenience in coding, ADS is expressed in two groups of 4 bits each, ADS1, 33 through 36, and ADS2, 37 through 40. A TCAS Sensitivity Level Command Message **shall** use ADS1=0 and ADS2=5.

SLC: TCAS Sensitivity Level Command – This 4-bit (bits 41 – 44) subfield contains a sensitivity level command for the TCAS aircraft.

The transponder **shall** monitor the TMS (see §2.2.19.2.1.1.c) and ADS subfields of Comm-A interrogations UF=20 and 21. If ADS1=0 and ADS2=5 and TMS=0, the IIS subfield of SD and the SLC subfield of MA **shall** be provided to the TCAS unit.

2.2.22.1.2 MB Message, Comm-B Used by TCAS

Airborne equipment **shall** use the MB field (see §2.2.14.4.21) of Comm-B replies to transmit a Resolution Advisories Report and a Data Link Capability Report to Mode S sensors.

2.2.22.1.2.1 Air-Initiated Downlink of RA Report

2.2.22.1.2.1.1 Air-Initiated Downlink of RA Report for All Transponder/TCAS Systems

The following requirements apply to all transponder/TCAS systems, i.e., both those that are compatible with RTCA/DO-185A/B, and those that are **NOT** compatible with RTCA/DO-185A/B.

Whenever TCAS reports that it has an active Resolution Advisory (RA), the transponder **shall** indicate that it has an RA Report awaiting downlink by setting the DR field in DF=4, 5, 20, 21 replies to DR=2, 3, 6, or 7 as appropriate.

Upon receipt of a DF=4, 5, 20, or 21 reply, with DR=2, 3, 6 or 7, a Mode S sensor may request downlink of the RA Report by setting RR=19 and DI≠3 or 7, or RR=19, DI=3 or 7 and RRS=0 in a surveillance or Comm-A interrogation (UF=4, 5, 20, or 21) to the TCAS aircraft. When this request is received by own Mode S transponder, own transponder **shall** reply with a Comm B reply, DF=20, 21, whose MB field contains an RA Report with information previously provided to the transponder by the TCAS equipment.

While an RA is active, the content of the MB field in the RA Report **shall** be updated at least once every second. DR=2, 3, 6 or 7 **shall** remain set for 18 ±1 seconds following the end of the RA. In addition, the RA Report **shall** remain "frozen," i.e., **shall** retain the last ARA and the corresponding RAC, for 18 ±1 seconds following the end of the RA, unless superseded by a new ARA.

Subfields in MB for RA Report

BDS: B-Definition Subfield – This 8-bit (bits 33 – 40) subfield indicates that a RA Report is contained in MB by BDS1=3 and BDS2=0, the combination of which is equivalent to BDS=48.

ARA: Active Resolution Advisories – This 14-bit (bits 41 – 54) subfield indicates the currently active RAs (if any) generated by own TCAS unit against one or more threat aircraft.

RAC: Resolution Advisory Complements – This 4-bit (bits 55 – 58) subfield indicates the currently active RA complements (if any) received from other TCAS aircraft equipped with on-board resolution capability.

2.2.22.1.2.1.2 Air-Initiated Downlink of RA Report for FAA TSO-C119a Compatible Systems

The following requirements apply to all FAA TSO-C119a compatible transponder/TCAS systems in addition to the requirements provided in §2.2.22.1.2.1.1.

An active RA is identified as being any NON-ZERO ARA.

2.2.22.1.2.1.3 Air-Initiated Downlink of RA Report for RTCA/DO-185A Compatible Systems

The following requirements apply to all RTCA/DO-185A/B compatible transponder/ TCAS systems in addition to the requirements provided in §2.2.22.1.2.1.1.

Subfields in MB for RA Report

BDS: B-Definition Subfield – Additional Information

When BDS1=3 and BDS2 =0, the subfields indicated below are contained in MB. For 18 ±1 seconds following the end of an RA, all MB subfields in the RA report with the exception of bit 59 (RAT) **shall** retain the information reported at the time the RA was last active.

Except for the RAT bit, the following subfields are provided to the transponder by the TCAS for application in the RA Report.

RAT: Resolution Advisory Terminated Indicator – This 1-bit (bit 59) subfield **shall** be set by the transponder to indicate when an RA previously generated by TCAS has ceased being generated. RAT **shall** be set in accordance with the following:

0 = The RA indicated by the ARA subfield is currently active. The transponder **shall** set RAT to ZERO at all times except those defined for RAT =1.

1 = The RA indicated by the ARA subfield has been terminated. RAT **shall** be set to ONE for 18 ±1 seconds following termination of a previously reported RA. Termination of the RA may result from any of the following:

a. Notification of termination of the RA received from own on-board TCAS.

b. Notification of loss of capability received from own on-board TCAS, i.e., TCAS declaration of interface failure.

c. Transponder declaration of interface failure.

The transponder **shall** monitor the 1-bit RA Indicator (RAI) from TCAS to determine whether there is an active RA. RAI is set to ZERO by TCAS to indicate that there is an active RA. Otherwise, RAI is set to ONE by TCAS. Termination of the RA is indicated by the transition of RAI from ZERO to ONE.

Note: *The RAT bit is used to indicate that the RA has been terminated. It may be used, for example, to permit removal of an RA indication from an Air Traffic Control display, or for assessment of RA duration within a particular airspace.*

MTE: Multiple Threat Encounter – This 1-bit (bit 60) subfield indicates whether two or more simultaneous threats are currently being processed by the TCAS threat resolution logic.

TTI: Threat Type Indicator – This 2-bit (bits 61 – 62) subfield defines the type of identity data contained in the TID subfield (see §2.2.22.1.2.1.3).

TID: Threat Identity Data – This 26-bit subfield (bits 63 – 88) contains the Mode S address of the threat if the threat is equipped with a Mode S transponder. If the threat is not equipped with a Mode S transponder, then this subfield contains the altitude, range, and bearing of the threat.

If two or more threats are simultaneously being processed by the TCAS threat resolution logic, the TID subfield contains the identity or position data for the most recently declared threat.

If TTI=1, the TID subfield contains the Mode S address of the threat in bits 63 through 86, and bits 87 through 88 are set to ZERO.

If TTI=2, the TID subfield contains the following three subfields.

TIDA: Threat Identity Data, Altitude – This 13-bit subfield (bits 63 – 75) contains the most recently reported Mode-C altitude code of the threat. Coding of the TIDA subfield is consistent with the coding of the Mode-C Altitude reply.

TIDR: Threat Identity Data, Range – This 7-bit subfield (bits 76 – 82) contains the most recent range of the threat estimated by TCAS.

TIDB: Threat Identity Data, Bearing – This 6-bit subfield (bits 83 – 88) contains the most recent bearing of the threat estimated by TCAS, relative to the TCAS aircraft heading.

2.2.22.1.2.2 Data Link Capability Codes in MB

2.2.22.1.2.2.1 Data Link Capability Codes in MB for All Transponder/TCAS Systems

Notes:

1 *The ground-based Mode S sensor learns of the specific data link capabilities on board the aircraft by using the data link capability report protocol specified in §2.2.19.1.12.6, §2.2.19.1.12.6.1, §2.2.19.1.12.6.2, and §2.2.19.1.12.6.3.*

2. *The data bits discussed in the following subparagraphs are modified in the MB field of the Data Link Capability Report by the Mode S transponder such that the data appears appropriately in response to a request for Data Link Capability Report when BDS1=1 and BDS2=0. As such, these data bits comprise only a small fraction of the entire Data Link Capability Report which may collate data from multiple sources for transfer in the downlink. Care must be taken to ensure that the data fields discussed in the following subparagraphs are not compromised when other sources attempt to update the Data Link Capability Report, and that updating of these bits does not compromise other parts of the Data Link Capability Report.*

2.2.22.1.2.2.2 Data Link Capability Codes in MB for FAA TSO-C119a Compatible Systems

The following requirements apply to all FAA TSO-C119a compatible transponder/TCAS systems.

The Mode S transponder **shall** process the TCAS-supplied capability information (RI) for inclusion in the Data Link Capability Report. This capability information **shall** cause the transponder to set the following codes in a Data Link Capability Report:

Bit Codes in MB for Data Link Capability Report

The following codes **shall** appear in the MB field for a Data Link Capability Report when BDS1=1 and BDS2=0.

Bit 48 equals 1 indicates that the transponder/TCAS interface is operational and the transponder is receiving TCAS RI=2, 3 or 4.

Bits 69 and 70 form a capability code subfield which indicates the aircraft's on-board resolution advisory generation capability.

The codes are:

Bit 69	Bit 70	Meaning
0	0	No on-board resolution advisory generation capability (TCAS RI not equal to 3 or 4, or no operational interface.)
0	1	An on-board vertical-only resolution advisory generation capability exists (TCAS RI=3)
1	0	An on-board vertical and horizontal resolution advisory generation capability exists (TCAS RI=4)
1	1	Reserved

2.2.22.1.2.2.3 Data Link Capability Codes in MB for RTCA/DO-185A Compatible Systems

The following requirements apply to all RTCA/DO-185A compatible transponder/TCAS systems.

Bits 48, 69, 70, 71, and 72 are provided to the transponder by the TCAS and **shall** appear in the MB field for a Data Link Capability Report when BDS1=1 and BDS2=0.

Notes:

1. *Bit 71 set to ONE indicates that the transponder/TCAS system is compatible with RTCA/DO- 185A.*
2. *Bit 72 is "Reserved" for future use by TCAS and/or the transponder. Until appropriate coding of this bit has been defined, it should be set to ZERO (0) by the TCAS.*

If the transponder detects a failure of the transponder/TCAS interface, then the transponder **shall** ensure that Bits 48, 69, 70, 71, and 72 are set to ZERO in the Data Link Capability Report.

2.2.22.1.2.2.4 Data Link Capability Codes in MB for RTCA/DO-185B Compatible Systems

The following requirements apply to all RTCA/DO-185B compatible transponder/TCAS systems.

Bits 48, 69, 70, 71, and 72 are provided to the transponder by the TCAS and shall appear in the MB field for a Data Link Capability Report when BDS1=1 and BDS2=0.

Notes:

1. *Bit 48 ("MB" bit 16) set to ONE (1) indicates that the transponder TCAS interface is operational and the transponder is receiving TCAS RI=2, 3 or 4.*
2. *Bit 69 ("MB" bit 37) set to ONE (1) indicates capability of Hybrid Surveillance, and set to ZERO (0) indicates that there is no Hybrid Surveillance capability.*
3. *Bit 70 ("MB" bit 38) set to ONE (1) indicates that TCAS is generating both TAs and RAs, and set to ZERO (0) indicates the generation of TAs only.*
4. *Bits 71, 72 ("MB" bits 39, 40) are encoded in accordance with the following table:*

Bit 72	***Bit 71***	***Meaning***
"MB" Bit 40	***"MB" Bit 39***	
0	*0*	*RTCA DO-185 (6.04A) (FAA TSO-C119a)*
0	*1*	*RTCA DO-185A (FAA TSO-C119b)*
1	*0*	*RTCA DO-185B (FAA TSO-C119c)*
1	*1*	*Reserved for future versions*

If the transponder detects a failure of the transponder/TCAS interface, then the transponder **shall** ensure that Bits 48, 69, 70, 71, and 72 are set to ZERO in the Data Link Capability Report.

2.2.22.1.2.3 Additional MB Message Reserved for RTCA/DO-185A/B Compatible Systems

An RTCA/DO-185A/B compatible TCAS has the capability of sending the transponder a 56-bit message for storage into one of the Ground-Initiated Comm-B (GICB) registers. When operating in an RTCA/DO-185A/B compatible system, the transponder **shall** store the TCAS-supplied 56-bit message into the specified transponder GICB register. The GICB register specified for this purpose is Register $0F_{16}$.

Notes:

1. *The actual structure and coding of the TCAS MB Message is not specified in this document and may be defined in the future. It is the intent of RTCA/DO-185A/B compatible systems that the transponder/TCAS interface be implemented in a manner such that the TCAS can directly format the designated MB message and thereby alleviate the need for the transponder to know the exact structure and coding of the message.*

2. *Transponders designed for use in RTCA/DO-185A/B compatible systems should allow for future use of other MB messages sent by TCAS.*

2.2.22.1.3 MU Message, Comm-U Used by TCAS

The Mode S transponder **shall** supply the MU field (see §2.2.14.4.25) of a long special surveillance interrogation, UF=16, to TCAS only under the following conditions:

a. The interrogation contains the transponder's discrete address and UDS=48.

b. The interrogation contains the broadcast address (all ONES) and UDS=50.

Notes:

1. *The MU field is used by TCAS to transmit a TCAS Broadcast Interrogation Message containing own transponder's address for the purpose of controlling interference caused by TCAS interrogations, or to transmit a TCAS Resolution Message for air-to-air resolution advisory coordination.*

2. *Ideally the transponder should serve as a modem for TCAS and supply the entire MU field to TCAS (including the UDS Field) of any received UF=16 interrogation. Currently implemented transponder/TCAS interface protocols do not provide the UDS Field information to TCAS so it is necessary for these transponders to select the UDS messages that are passed to TCAS. If this interface limitation is removed in the future, then all UDS messages would be passed to TCAS.*

Subfield in MU for a TCAS Resolution Message

UDS: U-Definition Subfield – This 8-bit (bits 33 – 40) subfield defines the data content and coding in the remainder of the MU field. For convenience in coding, UDS is expressed in two groups of 4 bits each; UDS1, 33 through 36, and UDS2, 37 through 40. TCAS Resolution Messages **shall** be identified by UDS1=3 and UDS2=0, the combination of which is equivalent to UDS=48.

Subfield in MU for a TCAS Broadcast Message

UDS: U-Definition Subfield – A TCAS Broadcast Interrogation Message is identified by UDS1=3 and UDS2=2, the combination of which is equivalent to UDS=50.

2.2.22.1.4 MV Message, Comm-V Used by TCAS

2.2.22.1.4.1 MV Message, Comm-V Used by FAA TSO-C119a Compatible Systems

Upon acceptance of a UF=16 containing a TCAS Resolution Message from a threat TCAS aircraft, the Mode S transponder **shall** transmit a long special surveillance reply, DF=16, to the requesting aircraft. The MV field of this reply **shall** contain a Coordination Reply Message with information previously provided by own TCAS.

Subfields in MV for a Coordination Reply Message

ARA: Active Resolution Advisories – This 14-bit (bits 41 – 54) subfield as described in §2.2.22.1.2.1.1.

RAC: Resolution Advisory Complements – This 4-bit (bits 55 – 58) subfield as described in §2.2.22.1.2.1.1.

VDS: V-Definition Subfield – This 8-bit (bits 33 – 40) subfield defines the content and coding in the remainder of MV. For convenience in coding, VDS is expressed in two groups of 4 bits each; VDS1, bits 33 through 36, and VDS2, bits 37 through 40. The airborne TCAS equipment is a source of long special reply MV messages containing the VDS1=3 code. A Coordination Reply Message is identified by VDS1=3 and VDS2=0, the combination of which is equivalent to VDS=48.

2.2.22.1.4.2 MV Message, Comm-V Used by RTCA/DO-185A/B Compatible Systems

In addition to the requirements provided in §2.2.22.1.4.1, a RTCA/DO-185A/B compatible system **shall** provide the following:

Subfields in MV for a Coordination Reply Message

RAT: Resolution Advisory Terminated Indicator – This 1-bit (bit 59) subfield as described in §2.2.22.1.2.1.3.

MTE: Multiple Threat Encounter – This 1-bit (bit 60) subfield as described in §2.2.22.1.2.1.3.

2.2.22.1.5 RI Air-to-Air Reply Information

This 4-bit (bits 14 – 17) downlink field **shall** be included in special surveillance formats DF=0, 16. This field **shall** contain information pertaining to replying aircraft. Where airspeed is reported (see §2.2.14.4.33), the maximum true airspeed flown in normal operations **shall** be given using the coding shown below.

In addition to the RI coding in §2.2.14.4.33, a TCAS-Compatible Mode S transponder **shall** be capable of receiving additional RI codes from own TCAS for inclusion in special surveillance formats DF=0, 16 for replies to non-acquisition interrogations.

The codes are:

Code	Meaning
0	No on-board TCAS
1	Reserved
2	On-board TCAS with resolution capability inhibited
3	On-board TCAS with vertical-only resolution capability
4	On-board TCAS with vertical and horizontal resolution capability
5 – 7	Reserved
8	No maximum airspeed data available
9	Airspeed is less than or equal to 75 knots
10	Airspeed is greater than 75 and less than or equal to 150 knots
11	Airspeed is greater than 150 and less than or equal to 300 knots
12	Airspeed is greater than 300 and less than or equal to 600 knots
13	Airspeed is greater than 600 and less than or equal to 1200 knots
14	Airspeed is greater than 1200 knots
15	Reserved

The following protocol **shall** apply:

On receipt of a short special interrogation, UF=0, or a long special interrogation, UF=16, the interrogated Mode S transponder **shall** reply with a short special reply, DF=0, or a long special reply, DF=16, depending on the code contained in the RL field of the interrogation. In this reply, the sensitivity level and the air-to-air reply information **shall** be supplied in the SL and RI fields. The Mode S transponder **shall** transmit the SL field supplied by TCAS to indicate the sensitivity level at which TCAS is currently operating.

Bit 14 of the RI field replicates the AQ bit (see §2.2.14.4.5) of the interrogation. That is, codes 0 – 7 are supplied by TCAS for use in the reply to an air-to-air non-acquisition interrogation; codes 8 – 15 (indicating aircraft maximum airspeed) **shall** be supplied by the Mode S transponder for use in the reply to an acquisition interrogation. For a reply to a non-acquisition interrogation, the Mode S transponder **shall** set the RI field to ZERO (0) to indicate a non-operational TCAS if the conditions for setting bit 48 to ONE (1) (see §2.2.22.1.2.2) are not satisfied. If RI=0, the SL field has no meaning.

2.2.22.2 General Requirements of the Mode S Interface to the TCAS Equipment

2.2.22.2.1 Delivery of Messages

The transponder **shall** transmit a valid Coordination Reply Message in response to an incoming TCAS Resolution Message if, and only if, current transponder indications show that the incoming message can be delivered to the TCAS unit. If the transponder recognizes a valid incoming TCAS Resolution Message but does not send a valid Coordination Reply Message, all data in the incoming message **shall** be discarded.

Note: *This requirement implies that the manufacturer must determine the rate at which incoming interrogations can actually be accepted by the transponder (generally a rate much greater than detailed in §2.2.22.b) and the rate at which these interrogations can be passed to the TCAS unit and, if necessary, provide a queuing mechanism to ensure that accepted interrogations are not lost. The transponder must be able to monitor the status of the queue and the status of any other relevant internal structures or pathways so as not to accept new TCAS Resolution Messages if the queue is full or if there is some other condition that would prevent delivery to the TCAS unit (e.g., the transponder/TCAS interface is not established or has failed or TCAS is indicating no resolution capability).*

If the transponder cannot accept the incoming TCAS Resolution Message contained in the MU field of a long special surveillance interrogation UF=16, the transponder **shall** either (a) not reply to this interrogation, or (b) reply with a long special surveillance reply DF=16 with all 56 bits of the MV field equal to ZERO (0).

2.2.22.2.2 Data Integrity

The interface between TCAS and the transponder **shall** be designed to provide communication in the normal operational aircraft environment for that class of TCAS equipment while assuring error rates of less than one detected error in 10^5 bit transmissions and less than one undetected error in 10^9 bit transmissions for transfers in either direction. Compliance with this requirement **shall** be demonstrated either by direct test in a simulated operational environment or by analysis based on the known characteristics of proven interface techniques.

The Mode S transponder **shall** monitor the status of the communications interface with own TCAS. A detected failure in the interface **shall** be recognized by the transponder as a loss of integrity and **shall** be treated as a TCAS failure (see §2.2.22.1.5 and §2.2.19.1.12.6).

Note: *Incomplete data transmission can result in erroneous execution of the TCAS logic algorithms.*

2.2.22.2.3 TCAS Failure Data Handling

When a TCAS failure is detected, the transponder **shall** set all areas for storage of TCAS data to ZERO.

2.2.22.2.4 Communication Timing

TCAS Resolution Messages that are received by the transponder **shall** be delivered to the TCAS unit (received by TCAS from the TCAS/transponder interface) within 0.01 second of receipt by the transponder.

Note: *This requirement assumes the transponder input message rate of one message every 16.6 milliseconds (60 per second).*

2.2.22.3 Data Provided by TCAS Equipment to the Mode S Transponder

2.2.22.3.1 Data Contained in the Special Surveillance Replies (DF=0, 16)

a. Contents of the SL Field

The Mode S transponder **shall** report a changed value of the sensitivity level in the SL field in any special surveillance reply, DF=0, 16 generated no later than 250 milliseconds after receipt of the changed SL value from TCAS.

b. Contents of the RI Field

The TCAS equipment provides a value for downlink transmission by the transponder in the RI field whenever the corresponding UF=0 or 16 interrogation contains AQ=0 (tracking interrogation). The Mode S transponder **shall** report a changed resolution capability in any special surveillance reply, DF=0, 16 generated no later than one second after receipt of the changed RI value from TCAS.

2.2.22.3.2 Data Contained in the Long Special Surveillance Reply (DF=16)

When the Mode S transponder receives a long special surveillance interrogation (UF=16) with RL=1 and UDS=48 in the MU field, the transponder **shall** reply with a long special surveillance reply, DF=16. This reply **shall** contain a Coordination Reply Message (see §2.2.22.1.4), the contents of which were provided previously by the TCAS equipment.

2.2.22.3.3 Data Contained in Altitude and Identity Surveillance and Comm-B Replies (DF=4, 5, 20, 21)

Contents of the DR Field

The TCAS equipment provides a continuous indication to the Mode S transponder whenever a TCAS resolution advisory exists. This **shall** cause the transponder to set either code 2, 3, 6 or 7 in the DR field (see §2.2.14.4.13) within one second of first receipt of this indication.

2.2.22.3.4 Data Contained in the Altitude and Identity Comm-B Reply (DF=20, 21)

a. Resolution Advisories Report

When the Mode S transponder receives an altitude or identity surveillance or Comm-A interrogation, UF=4, 5, 20 or 21 with RR=19, the transponder **shall** reply with a Comm-B, DF=20, 21. This reply **shall** contain a Resolution Advisories Report (§2.2.22.1.2.1).

b. Data Link Capability Report

The TCAS equipment indicates to the Mode S transponder its resolution capabilities, which the transponder **shall** include in the Data Link Capability Report (see §2.2.22.1.2.2).

Note: *§2.2.19.1.12.6.3 specifies that the transponder will recognize a change in on-board data link capability and will automatically set DR=4, 5, 6 or 7, causing the ground system to read out a new Data Link Capability Report.*

2.2.22.4 Data Provided by the Mode S Transponder to the TCAS Equipment

The transponder **shall** provide the following data to the TCAS equipment:

a. The aircraft discrete address,

b. The aircraft pressure altitude from the source that is the basis for own altitude in Mode C and Mode S replies,

c. Quantization for pressure altitude (defined to be 25 feet or less, or 100 feet).

Note: *Selection of the altitude source to be used for altitude reporting is typically made by the flight crew. As such, the requirements of the previous paragraph are a function of the operational installation and not the transponder directly.*

2.2.22.5 TCAS-Compatible Transponder Automatic Performance Monitoring

The transponder **shall** be capable of detecting malfunctions in the Mode S transponder system that would degrade TCAS functioning and upon detection **shall** make this information available to TCAS.

2.2.23 Extended Squitter (ES)

2.2.23.1 ADS-B Extended Squitter

Mode S transponders may provide the capability to transmit Extended Squitters to support the broadcast of aircraft-derived position, identification and state information.

Note: *The broadcast of this type of information is a form of Automatic Dependent Surveillance (ADS) known as ADS-Broadcast or ADS-B.*

2.2.23.1.1 Extended Squitter Format

The format used for the Extended Squitter **shall** be the 112-bit downlink format DF=17 using II=0 and SI=0 in generating the PI field (§2.2.14.4.30).

2.2.23.1.2 Extended Squitter Types

a. Airborne Position Squitter. The airborne position Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 05_{16} inserted in the ME field.

   Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS=5 will cause the resulting reply to contain the airborne position report in its MB field.*

b. Surface Position Squitter. The surface position Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 06_{16} inserted in the ME field.

   Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS equals 6 will cause the resulting reply to contain the surface position report in its MB field.*

c. Aircraft Identification and Category Squitter. The aircraft identification and category Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 08_{16} inserted in the ME field.

   Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS equals 8 will cause the resulting reply to contain the aircraft identification and category report in its MB field.*

d. Airborne Velocity Squitter. The airborne velocity Extended Squitter **shall** use format DF=17 with the contents of GICB Register 09_{16} inserted in the ME field.

   Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS equals 9 will cause the resulting reply to contain the airborne velocity report in its MB field.*

e. Target State and Status. The airborne Target State and Status Extended Squitter **shall** use format DF=17 with the contents of GICB Register 62_{16} inserted in the ME field.

   Note: *A GICB request (see §2.2.19.1.12.3) containing RR=22 (e.g., BDS1=6), DI=3 or 7 and RRS=2 (e.g., BDS2=2) will cause the resulting reply to contain the airborne Target State and Status report in its MB field.*

f. Aircraft Operational Status. The airborne or surface Aircraft Operational Status Extended Squitter shall use format DF=17 with the contents of GICB Register 65_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=22 (e.g., BDS1=6), DI=3 or 7 and RRS=5 (e.g., BDS2=5) will cause the resulting reply to contain the Aircraft Operational Status report in its MB field.*

g. Event-driven Squitter. The event-driven Extended Squitter **shall** use format DF=17 with the contents of GICB Register $0A_{16}$ inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS=0A will cause the resulting reply to contain the event-driven report in its MB field. Since multiple Register contents can be multiplexed through Register 61_{16} and $0A_{16}$, GICB extractions of these Registers is not recommended as the reply could be indeterminate.*

2.2.23.1.3 Extended Squitter Rate

a. Initialization. At power up initialization, the transponder **shall** commence operation in a mode in which it broadcasts only acquisition squitters (see §2.2.18.2.6). The transponder **shall** initiate the broadcast of Extended Squitters for airborne position, surface position, airborne velocity, target state and status, aircraft operational status and aircraft identification and category when data are inserted into GICB Registers 05_{16}, 06_{16}, 09_{16}, 62_{16}, 65_{16} and 08_{16} respectively. This determination **shall** be made individually for each squitter type. The insertion of altitude data into Register 05_{16} by the transponder (see §2.2.23.1.8) **shall not** satisfy the minimum requirement for broadcast of the airborne position squitter.

Note 1: *This suppresses the transmission of Extended Squitters from aircraft that are unable to report position, velocity or identity information.*

If input to Register 05_{16} and 06_{16} stops for 60 seconds, broadcast of that Extended Squitter type will be discontinued until data insertion is resumed. The insertion of altitude by the transponder **shall** satisfy the minimum requirement for continuing to broadcast the airborne position squitter. After timeout (see §2.2.23.1.4.2), this squitter type may contain an ME field of ALL ZEROs.

Note 2: *Continued transmission for 60 seconds is required so that receiving aircraft will know that the data source for the message has been lost.*

When Extended Squitters are broadcast, transmission rates **shall** be as indicated in the following paragraphs. Acquisition squitters **shall** be reported in addition to Extended Squitters as specified in §2.2.18.2.6.c. Acquisition squitters **shall** always be reported if no Extended Squitters are reported.

b. Airborne Position Squitter Rate. Airborne position squitter transmissions **shall** be emitted as specified in §2.2.23.1.5 at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization no greater than 15 milliseconds relative to the previous airborne position squitter, with the exceptions as specified in subparagraph "i."

c. Surface Position Squitter Rate. Surface position squitter transmissions **shall** be emitted as specified in §2.2.23.1.5 using one of two rates depending upon whether the high or low squitter rate has been selected (see §2.2.23.1.6). When the high squitter rate has been selected, surface position squitters **shall** be emitted at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization no greater than 15 milliseconds relative to the previous surface position squitter (termed the high rate). When the low squitter rate has been selected, surface position squitters **shall** be emitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds using a time quantization no greater than 15 milliseconds relative to the previous surface position squitter (termed the low rate) Exceptions to this transmission rate are specified in subparagraph "i."

Notes:

1. *High and low squitter rate status is determined on board the aircraft.*

2. *The low rate is used when the aircraft is stationary and the high rate is used when the aircraft is moving.*

d. Aircraft Identification and Category Squitter Rate. Aircraft identification and category squitter transmissions **shall** be emitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds using a time quantization no greater than 15 milliseconds relative to the previous identification and category squitter when the aircraft is reporting the airborne position squitter, or when the aircraft is reporting the surface position squitter and the high surface squitter rate has been selected. When the surface position squitter is being reported at the low surface rate, the aircraft identification and category squitter **shall** be emitted at random intervals that are uniformly distributed over the range of 9.8 to 10.2 seconds using a time quantization no greater than 15 milliseconds relative to the previous identification and category squitter. Exceptions to these transmission rates are specified in subparagraph "i."

e. Airborne Velocity Squitter Rate. Airborne velocity squitter transmissions **shall** be emitted as specified in §2.2.23.1.5 at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization no greater than 15 milliseconds relative to the previous velocity squitter, with the exceptions as specified in subparagraph "i."

f. Airborne Target State and Status Squitter Rate. Airborne Target State and Status squitter **shall** be transmitted at rates as specified in §2.2.3.3.1.4.1 of RTCA DO-260B / EUROCAE ED-102A.

   Verification of the transmission rates of Airborne Target State and Status Messages **shall** be performed in accordance with §2.4.3.3.1.4.1 of RTCA DO-260B / EUROCAE ED-102A.

g. Aircraft Operational Status Squitter Rate. The Aircraft Operational Status squitter shall be transmitted at the rates as specified in §2.2.3.3.1.4.2 of RTCA DO-260B / EUROCAE ED-102A, with the exceptions as specified in subparagraph "i." When transmitting the surface formats, the rate depends on whether the high or low squitter rate has been selected (see §2.2.23.1.6).

   Verification of the transmission rates of Aircraft Operational Status Messages **shall** be performed in accordance with §2.4.3.3.1.4.2 of RTCA DO-260B / EUROCAE ED-102A.

h. Event-Driven Squitter Rate. The event-driven squitter **shall** be transmitted once, each time that GICB Register $0A_{16}$ is loaded, while observing the delay conditions specified in subparagraph "i." The maximum transmission rate for the event-driven squitter **shall** be limited by the transponder to twice per second. If a message is inserted in the event-driven register and cannot be transmitted because of rate limiting, it **shall** be held and transmitted when the rate limiting condition has cleared If a new message is received before transmission is permitted, it **shall** overwrite the earlier message.

Notes:

1. *The squitter transmission rate and the duration of squitter transmissions is application dependent. Choices made should be the minimum rate and duration consistent with the needs of the application.*

2. *The broadcast rates for Event-Driven Messages are defined in RTCA DO-260B / EUROCAE ED-102A, §2.2.3.3.1.4.6.1.*

i. Delayed Transmission. Extended squitter transmission **shall** be delayed in the following circumstances:

(1) the scheduled Extended Squitter **shall** be delayed if the transponder is in a transaction cycle (see §2.2.18.2.2.k); or

(2) the scheduled Extended Squitter **shall** be delayed if an acquisition or another type of Extended Squitter is in process; or

(3) the scheduled Extended Squitter **shall** be delayed if a mutual suppression interface is active.

Note: *A mutual suppression system may be used to connect on-board equipment operating in the same frequency band in order to prevent mutual interference. Squitter action resumes as soon as practical after a mutual suppression interval.*

The delayed squitter **shall** be transmitted as soon as the condition causing the delay no longer exists.

2.2.23.1.4 Transponder Support for Extended Squitter Registers

2.2.23.1.4.1 Data Insertion

When the transponder determines that it is time to emit an airborne position squitter, it **shall** insert the current value of the barometric altitude (unless inhibited by the ATS subfield, §2.2.23.1.9) and surveillance status into the appropriate fields of Register 05_{16}. The contents of this Register **shall** then be inserted into the ME field of DF=17 and transmitted.

Note: *Insertion in this manner ensures that (1) the squitter contains the latest altitude and surveillance status, and (2) ground readout of Register 05_{16} will yield exactly the same information as contained in the previous squitter.*

2.2.23.1.4.2 Register Timeout and Termination

2.2.23.1.4.2.1 Timeout of Extended Squitter Messages

a. Timeout of Extended Squitter Messages **shall** be performed in accordance with §2.2.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A.

b. Verification of Extended Squitter Message timeout functions **shall** be performed in accordance with §2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A.

2.2.23.1.4.2.2 Termination of Extended Squitter Messages

a. Termination of Extended Squitter Messages **shall** be performed in accordance with §2.2.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A.

b. Verification of Extended Squitter Message termination functions **shall** be performed in accordance with §2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A.

2.2.23.1.5 Airborne/Surface Format Selection

2.2.23.1.5.1 Automatic Format Selection

The criteria for selection of airborne or surface formats are contained in the latest version of §2.2.3.2.1.2 of RTCA DO-260B [EUROCAE ED-102A].

2.2.23.1.5.2 Ground Controlled Format Selection

Aircraft without such automatic means **shall** report the airborne type formats. Aircraft with or without such automatic on-the-ground determination **shall** report the surface type formats as commanded by control codes in the TCS subfield (see §2.2.23.1.7). After timeout of the TCS commands, control of airborne / surface type formats **shall** revert to the means described above.

Note 1: *Extended squitter ground stations determine aircraft airborne or on-the-ground state by monitoring aircraft position, altitude and ground speed. Aircraft determined to be on-the-ground that are not reporting the surface type formats may be commanded to report the surface type formats via the TCS subfield. The normal return to the airborne type formats is via a ground command to report the airborne type formats. To guard against loss of communications after takeoff, commands to report the surface type formats automatically timeout.*

When commanded to report the surface type format by TCS commands, aircraft without automatic means of determining the on-the-ground condition, and aircraft with such means that are reporting airborne state, **shall** transmit acquisition squitters as specified in §2.2.18.2.6.a.

Note 2: *Transmission of the acquisition squitter will provide for TCAS acquisition in the event that an airborne aircraft is commanded to report the surface type formats. In this case, the CA field of the acquisition and Extended Squitters will continue to show that the aircraft is airborne, or is unable to determine its on-the-ground state.*

2.2.23.1.6 Surface Squitter Rate Control

Surface squitter rate **shall** be determined as follows:

a. Once per second the contents of the TRS (see §2.2.23.1.9) **shall** be read. If the value of TRS is 0 or 1, the transponder **shall** transmit surface squitters at the high rate. If the value of TRS is 2, the transponder **shall** transmit surface squitters at the low rate.

b. The squitter rate determined via the TRS subfield **shall** be subject to being overridden by commands received via the RCS subfield (see §2.2.23.1.7). RCS code 1 **shall** cause the transponder to squitter at the high rate for 60 seconds. RCS code 2 **shall** cause the transponder to squitter at the low rate for 60 seconds. These commands **shall** be able to be refreshed for a new 60 second period before timeout of the prior period.

c. After timeout and in the absence of RCS codes 1 and 2, control **shall** return to the TRS subfield.

2.2.23.1.7 Subfields in SD for Extended Squitter

The SD field contains the following information if the DI code is 2.

2.2.23.1.7.1 Type Control Subfield (TCS) in SD for Extended Squitter

TCS, the 3-bit (bits 21 – 23) Type Control Subfield in SD **shall** control the extended squitter airborne and surface format types reported by the transponder, and its response to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations. These commands **shall** only affect the format type that is reported, they **shall not** change the aircraft determination of its on-the-ground condition. The commands for codes 1 and 2 **shall** be able to be refreshed for a new period before timeout of the prior period.

Note 1: *Thus aircraft without the means to set the on-the-ground condition will continue to report code 6 in the CA field, and an aircraft with the means to set the on-the-ground condition that has determined that it is in the airborne state will continue to set code 5, independent of the Extended Squitter format that is emitted.*

The following TCS codes have been assigned:

TCS Codes	Description
0	No surface format types or reply inhibit command
1	See §2.2.23.1.7.1.1
2	See §2.2.23.1.7.1.2
3	Cancel surface format types and reply inhibit commands
4 – 7	Reserved

2.2.23.1.7.1.1 TCS Equal to ONE (1)

(a) Broadcast of the extended squitter surface formats, including the Surface Position Message, the ID and Category Message, the Aircraft Operational Status Message and the Aircraft Status Message for the next 15 seconds at the appropriate rates (see Table 2-79 in RTCA DO-260B / EUROCAE ED-102A) on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (see §2.2.12.5.2.b).

(b) Inhibit replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations for the next 15 seconds.
(c) Broadcast of acquisition squitters as per §2.2.18.2.6 and Table 2-2 using antenna as specified in §2.2.12.5.1.a.
(d) Does not impact the air/ground state reported via the CA, FS and VS fields.
(e) Discontinue broadcast of the extended squitter airborne message formats.
(f) Broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

2.2.23.1.7.1.2 TCS Equal to 2

(a) Broadcast of the extended squitter surface formats, including the Surface Position Message, the ID and Category Message, the Aircraft Operational Status Message and the Aircraft Status Message for the next 60 seconds at the appropriate rates (see Table 2-79 in RTCA DO-260B / EUROCAE ED-102A) on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (see §2.2.12.5.2.b).
(b) Inhibit replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations for the next 60 seconds.
(c) Broadcast of acquisition squitters as per §2.2.18.2.6 and Table 2-2 using antenna as specified in §2.2.12.5.1.a.
(d) Does not impact the air/ground state reported via the CA, FS and VS fields.
(e) Discontinue broadcast of the extended squitter airborne message formats.
(f) Broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

2.2.23.1.7.2 Rate Control Subfield (RCS) in SD for Extended Squitter

RCS, the 3-bit (bits 24 – 26) Rate Control Subfield in SD **shall** control the squitter rate of the transponder when it is reporting the Extended Squitter surface type formats. This subfield **shall** have no effect on the transponder squitter rate when it is reporting the Extended Squitter airborne type formats.

Note 2: *Aircraft without the means of determining on-the-ground state or aircraft with such means that are declaring the airborne state must be commanded to transmit the surface format (via TCS) before they can be controlled by this subfield. Both of these commands may be sent in the same interrogation.*

Note 3: *Both TCS and RCS have specific timeout periods. If the surface format command times out first, the aircraft will resume broadcasting the airborne format (unless it is now declaring the on-the-ground state or the surface format is selected in accordance with the requirements of §2.2.3.2.1.2 (3) of RTCA DO-260B / EUROCAE ED-102A).*

The following RCS codes have been assigned:

RCS Codes	Description
0	No surface Extended squitter rate command
1	Report high surface Extended squitter rate for 60 seconds
2	Report low surface Extended squitter rate for 60 seconds
3 – 7	Reserved

Acquisition squitters **shall** be emitted during the time period when Extended Squitters are inhibited as specified in §2.2.18.2.6.c.

Note 4: *The definition of high and low squitter rate is given in §2.2.23.1.3 and applies to the Surface Position, Aircraft Identification and Category, and the Operational Status Messages.*

Note 5: *As stated in §2.2.18.2.6.b.4, Acquisition squitters are transmitted when Surface type format Extended Squitters are not being transmitted.*

2.2.23.1.7.3 Surface Antenna Subfield (SAS) in SD for Extended Squitter

SAS, the two bit (bits 27 – 28) surface antenna subfield in SD **shall** control the selection of the diversity antenna that is used for: (1) the Extended Squitter when it is reporting the surface type formats, and (2) the acquisition squitter when the aircraft is reporting the on-the-ground condition. This subfield **shall** have no effect on the transponder diversity antenna selection when the aircraft is reporting the airborne status type, or if the aircraft does not have diversity antennas. When reporting the surface type formats, the default **shall** be the top antenna. The following SAS codes have been assigned:

SAS Codes	Description
0	No antenna command
1	Alternate top and bottom antennas for 120 seconds
2	Use bottom antenna for 120 seconds
3	Return to the default

2.2.23.1.8 Subfields in ME for Extended Squitter

SSS, the 2-bit (bits 38 – 39) Surveillance Status Subfield in ME **shall** report the surveillance status of the transponder when this field contains the airborne position squitter report. The following SSS codes have been assigned:

SSS Codes	Description
0	No status information
1	Transponder reporting permanent alert condition (§2.2.18.2.7.a)
2	Transponder reporting a temporary alert condition (§2.2.18.2.7.a)
3	Transponder reporting SPI condition (§2.2.18.2.7.d)

Codes 1 and 2 **shall** take precedence over code 3.

ACS, the 12-bit (bits 41 – 52) Altitude Code Subfield in ME **shall** (under control of the ATS subfield, §2.2.23.1.9) report the barometric altitude when this field contains an airborne position report. The contents of the ACS subfield **shall** be as specified for the 13-bit AC field (§2.2.14.4.2) except that the M bit (bit 26) **shall** be omitted. When barometric altitude is being reported, the contents of the ACS subfield **shall** be inserted by the transponder from the same source that would be used to provide the altitude field of a reply to a discrete interrogation. Transponder insertion of altitude data in the ACS subfield **shall** take place when the 1-bit ATS subfield has the value of ZERO. Transponder insertion of altitude data in the ACS subfield **shall** be inhibited when the ATS subfield has the value ONE.

Note: *An ATS subfield of ONE is provided for the future use of navigation-derived height (derived external to the transponder) in place of transponder provided barometric altitude.*

2.2.23.1.9 Subfields in MB for Extended Squitter

A ground-initiated Comm-B request (§2.2.19.1.12.3) containing RR=16 and DI=3 or 7, and RRS=7 **shall** cause the resulting reply to contain the Squitter Status Report in its MB field.

TRS, the 2-bit (bits 33 – 34) Transmission Rate Subfield in the Squitter Status Report **shall** report the capability of the aircraft to automatically determine its surface squitter rate and its current squitter rate.

The following TRS codes have been assigned:

TRS Codes	Description
0	No capability to automatically determine surface squitter rate
1	Aircraft has selected the high surface squitter rate
2	Aircraft has selected the low surface squitter rate
3	Reserved

Note 1: *High and low squitter rate status is determined on board the aircraft.*

Note 2: *The low rate is used when the aircraft is stationary and the high rate is used when the aircraft is moving.*

ATS, the 1-bit Altitude Type Subfield in the Squitter Status Report **shall** report the type of altitude being provided in the airborne Extended Squitter in the 1-bit (35) ATS subfield of MB when the reply contains the contents of transponder Register 07_{16}.

The following ATS codes have been assigned:

0 = barometric altitude is being reported
1 = navigation-derived height is being reported

Note 3: *ATS is set external to the transponder function.*

2.2.23.2 Event-Driven Squitter

The Event-Driven Squitter is broadcast each time data is loaded into GICB Register $0A_{16}$ as specified in §2.2.23.1.3. The transponder also makes available GICB Registers related to the Extended Squitter Event-Driven Squitter. The transponder **shall** provide data to the appropriate GICB Registers that are loaded into the Event-Driven GICB Register $0A_{16}$. The following GICB Register is currently defined for the Event-Driven Squitter:

BDS Code 6,1 Extended Squitter Aircraft Status

Note: *Additional information on the data content and transmission of these Extended Squitter Messages can be found in the latest version of RTCA DO-260B / EUROCAE ED-102A.*

2.2.23.3 Extended Squitter Military Application

Note: *This format supports the broadcast of Extended Squitter ADS-B messages in support of military applications. A separate format is used to distinguish these Extended Squitters from the standard ADS-B message set broadcast using DF=17 or 18.*

2.2.23.3.1 Military Format

The format used for DF=19 **shall** be a 112-bit downlink format containing the following fields:

Field	**Reference**
DF downlink format	§2.2.14.4.10
AF application field	§2.2.14.4.3

2.2.23.4 Extended Squitter Maximum Transmission Rate

The maximum total number of Extended Squitters (DF=17) emitted by any Extended Squitter installation **shall not** exceed 6.2 per second averaged over any 60 second interval, except during an emergency condition.

Note: *For installations capable of emitting extended squitters other than DF=17, see ICAO Annex 10, Vol IV, §3.1.2.8.9.*

2.2.24 Elementary Surveillance (ELS) Compliant Transponder

Elementary Surveillance has been defined as a functional capability necessary to support airspace operations in European airspace.

a. As a minimum, the transponder shall be a Level 2 transponder in accordance with §1.4.3.2 in order to support implementation of Elementary Surveillance functions.

b. The following subparagraphs summarize the functional aspects necessary to implement Elementary Surveillance.

Note: *The following subparagraphs do not declare actual requirements (e.g., "shall" statements). Such actual requirements are specified in subsequent subsections in order to establish traceability. The following subparagraphs are intended to introduce the Elementary Surveillance needs in order to improve understanding of the actual requirements provided in subsequent subsections.*

(1). Flight status reporting (FS) as described in §2.2.14.4.15. The Mode S transponder is capable of automatically acquiring the on-the-ground status as described in §2.2.18.2.7.

(2). Barometric pressure altitude reporting as described in §2.2.13.1.2.a.

(3). CA as specified in §2.2.14.4.6 (i.e., Greater than 3)

(4). II and SI code as defined in §2.2.14.4.18, §2.2.14.4.37, and with further details in §2.2.24.2.

(5). Declaration of capability in Register 10_{16} as described in §2.2.19.1.12.6.3 and with further detailed in §2.2.24.3.

(6). Aircraft Register 17_{16} as defined in §2.2.24.4.

(7). Aircraft Registers 18_{16} through $1C_{16}$ as defined in §2.2.24.5.

(8). Flight identification reporting in Register 20_{16} as detailed in §2.2.19.1.13 and further detailed in §2.2.24.6.

(9). As an option, Aircraft Register 21_{16}.

c. Optionally, the Mode S transponder must be capable of TCAS operation in accordance with all requirements defined in §2.2.22. In particular, the transponder reports TCAS capability and version in Register 10_{16} as well as the RA Report in Register 30_{16}.

Note: *For the remaining subsections of this section, servicing of a field or subfield in a register implies that valid data has been received at a sufficient rate to meet the update requirements specified for the given register in Appendix B.*

2.2.24.1 Ground Initiated Comm-B

Mode-S Transponders **shall** support extraction of Registers 10_{16}, 17_{16}, 18_{16} through $1C_{16}$, 20_{16} and 21_{16} (Optional) using the Ground Initiated Comm-B Protocols in accordance with §2.2.19.1.12.3.

Note: *In general, a Level 2 ELS capable transponder replies to all GICB register extraction request (see §2.2.19.1.12.3). If the requested register is not serviced by the transponder, then the "MB" field of the transponder reply contains All ZERO's.*

2.2.24.2 Surveillance Identifier ("SI") Code Requirements

2.2.24.2.1 MOPS Requirements Relevant to "SI"

Mode-S Transponders support the requirements of the Surveillance Identifier ("SI") codes in accordance with the following sections of this document.

a. §2.2.14.4.11, "DI" Designator, Identification Field
b. §2.2.14.4.18, "II" Interrogator Identification Field
c. §2.2.14.4.30, "PI" Parity / Interrogator Identity
d. §2.2.14.4.36, "SD" Special Designator and "IIS", Subfield in "SD"
e. §2.2.14.4.9, "CL" Code Label
f. §2.2.14.4.16, "IC" Interrogator Code
g. §2.2.14.4.37, "SI" Surveillance Identifier
h. §2.2.18.2.1, Basic Mode-S Error Protection
i. §2.2.18.2.5, "Multisite Lockout Protocol"
j. §2.2.18.2.6, "Acquisition Squitter"
k. §2.2.23.1.1, "Extended Squitter Format (DF=17)"
l. §2.2.18.2.9, "All-Call Reply Protocol"
m. §2.2.19.1.12.2, "Extended Data Source Designators"

Note: *Item "k." in regards to Extended Squitter" is included herein since the "SI" field must be set to "0" in generating the "PI" field in accordance with §2.2.14.4.30. Therefore, if the transponder implements Extended Squitter, then subparagraph "k." applies.*

2.2.24.3 Declaration of Capability in Register 10_{16} – Data Link Capability Report

2.2.24.3.1 Purpose and Definition

Register 10_{16} **shall** be formatted as specified in Appendix B, Table B-3-16 and associated notes.

Note: *The following subsections detail the minimum requirements for servicing Register 10_{16} in regards to Elementary Surveillance. Other fields in Register 10_{16} that do not pertain to Elementary Surveillance need to be managed in accordance with the additional capabilities supported by the transponder.*

2.2.24.3.2 Data Requirements

2.2.24.3.2.1 Bits 1 through 8, BDS Code

Bits 1 through 8 of Register 10_{16} shall be encoded with 10 HEX (0001 0000) (e.g., the BDS Register code).

Note: *The setting of the BDS Code by the transponder ensures that a broadcast change of the capability report will contain the BDS Code for all cases of data link failure (e.g., the loss of the transponder data link interface).*

2.2.24.3.2.2 Bits 17 through 23, Declaration of Mode S Subnetwork Number

Bits 17 through 23 of Register 10_{16} **shall** be encoded with the Mode-S Subnetwork Version Number in accordance with the following table:

<u>Table 2-4:</u> Mode S Subnetwork Version Number Encoding

<table>
<tr><th>Version Number</th><th>ICAO</th><th>RTCA</th><th>EUROCAE</th></tr>
<tr><td>0</td><td colspan="3">Mode S Subnetwork Not Available</td></tr>
<tr><td>1</td><td>ICAO Doc 9688 (1996)</td><td></td><td></td></tr>
<tr><td>2</td><td>ICAO Doc 9688 (1998)</td><td></td><td></td></tr>
<tr><td>3</td><td>ICAO Annex 10, Vol III, Amendment 77</td><td></td><td></td></tr>
<tr><td>4</td><td>ICAO Doc 9871, Edition 1</td><td>DO-181D</td><td>ED-73C</td></tr>
<tr><td>5</td><td>ICAO Doc 9871, Edition 2</td><td>DO-181E</td><td>ED-73E</td></tr>
<tr><td>6–127</td><td colspan="2">Reserved</td><td></td></tr>
</table>

To be consistent with Elementary and Enhance Surveillance requirements (e.g., this version of these MOPS), the Mode S Subnetwork Version Number **shall** be set to “5” or “higher”.

2.2.24.3.2.3 Bit 25, Declaration of No Mode S Specific Services Capability

Bit 25 of Register 10_{16} **shall not** be set to ONE (1) when reporting only Aircraft Identification in Register 20_{16} when no other Mode S Specific Services are supported by the transponder.

Notes:

1. *When Bit 25 is set to ONE (1), it indicates that at least one Mode S specific service is supported. Other capability reports need to be checked in order to determine which registers are supported. Mode S Specific Service refers to the servicing of Registers other than GICB services related to Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} through $1C_{16}$, 20_{16} and 30_{16}.*
2. *Bit 25 is used to indicate that Register 17_{16} should be extracted. The capability bits for the Enhanced Surveillance Registers 40_{16}, 50_{16}, and 60_{16} are used from Register 17_{16} to determine if the Enhanced Surveillance Registers should be extracted. In effect, Enhanced Surveillance functionality will not be detected unless bit 25 is set.*

2.2.24.3.2.4 Bit 33, Aircraft Identification Reporting Capability

Servicing of Register 20_{16} requires the updating of Register 10_{16} as follows:

a. Register 10_{16} (Data Link Capability Report) bit 33 **shall** be set to ONE (1) if the transponder is receiving any data from the Aircraft installation with which to service Register 20_{16} with Flight Identification or Aircraft Registration data as provided in the respective sections for each BDS Register in the subsequent sections of this document.

   Note: *This requirement is not established by the transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

b. Register 10_{16} (Data Link Capability Report) bit 33 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 20_{16}.

   Note: *When bit 33 of Register 10_{16} is changed, the change is broadcast as required in §2.2.19.1.13 and further defined in §2.2.24.4.*

2.2.24.3.2.5 Bit 35, Surveillance Identifier Code (SI)

Bit 35 of Register 10_{16} **shall** be set to ONE (1) to indicate that the transponder supports "SI" code capability.

Note: *"SI" code support is a mandatory requirement capability for all transponders.*

2.2.24.3.2.6 Bit 36, Common Usage GICB Capability Report

a. Register 10_{16} (Data Link Capability Report) bit 36 **shall** be toggled (i.e., changed from “0” to “1”, or from “1” to “0”) each time that the Common Usage GICB Capability Report (Register 17_{16}) is changed.

b. To avoid the generation of too many broadcast capability report changes, Register 17_{16} **shall** be sampled at approximately one minute intervals to check for changes that may require the toggling of bit 36 as discussed in subparagraph “a.”

2.2.24.3.3 Maximum Update Interval

a. The maximum update interval at which Register 10_{16} **shall** be reloaded with valid data is ≤ 4.0 seconds.

Note: *Effectively, Register 10_{16} must be updated every 4.0 seconds or sooner.*

b. Register 10_{16} **shall** be updated within one second of the data changing and at least every four seconds thereafter.

c. If a particular data field in Register 10_{16} cannot be updated within 8.0 seconds (e.g., twice the specified maximum update interval of≤ 4.0 seconds), then the data fie ld **shall** be ZEROed.

2.2.24.3.4 Change Reporting

When Register 10_{16} is changed, then the Register **shall** be broadcast as described in §2.2.19.1.12.6.3.

2.2.24.4 Register 17_{16}, Common Usage GICB Capability Report

2.2.24.4.1 Purpose and Definition

The format of Register 17_{16} **shall** be formatted as specified in Appendix B Table B-3-23 and associated notes.

Note: *The purpose of Register 17_{16} is to indicate which registers are currently supported by the aircraft installation, i.e., currently contain data useable for operational use.*

Elementary Surveillance transponders manage the following bits of Register 17_{16}:

a. Bit 7 to indicate servicing of Register 20_{16},

b. Bit 8 to indicate servicing of Optional Register 21_{16}.

2.2.24.4.2 Data Requirements

2.2.24.4.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16}

a. Register 17_{16} bit 7 **shall** be set to ONE (1) if the transponder is servicing either Aircraft Identification (also referred to as Flight Identification as specified in the Flight Plan) or Aircraft Registration data in the Aircraft installation.

Note: *This requirement is not established by the transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

b. Register 17_{16} bit 7 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 20_{16}.

2.2.24.4.2.2 Requiring Servicing of Register 17_{16} Associated with Optional Register 21_{16}

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs should be complied with.*

a. Register 17_{16} bit 8 shall be set to ONE (1) if the transponder is receiving Aircraft Registration data in the Aircraft installation.

   Note: *This requirement is not established by the transponder LRU own capability to service Register 21_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 21_{16}.*

b. Register 17_{16} bit 8 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 21_{16}.

2.2.24.4.3 Register 17_{16} Change Reporting

Whenever the contents of Register 17_{16} change, bit 36 of Register 10_{16} **shall** be toggled as defined in §2.2.24.3.2.6.

2.2.24.5 Register 18_{16} to $1C_{16}$, Mode S Specific Services Capability Report

2.2.24.5.1 Purpose and Definition

The Mode-S transponder **shall** format Register 18_{16} through $1C_{16}$ as defined in Appendix B, Table B-3-24 through Table B-3-28 and associated notes for Register 18_{16} through $1C_{16}$, respectively.

Note 1: *Registers 18_{16} to $1C_{16}$ are used to indicate the capability of the aircraft installation to provide data for each Register, i.e., the Register or a part of the Register is managed by the transponder and it is known that data can be received from the installation to fill this field.*

Note 2: *This is not established by the Transponder LRU own capability. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to service the corresponding Register. Once this capability is established it remains set until power off of the transponder.*

Transponders that support Elementary Surveillance functions manage Register 18_{16} as follows:

a. Register 18_{16} bit 41 to indicate that the installation has the capability to provide data in Register 10_{16}.

b. Register 18_{16} bit 34 to indicate that the installation has the capability to provide data in Register 17_{16}.

c. Register 18_{16} bit 33 to indicate that the installation has the capability to provide data in Register 18_{16}.

d. Register 18_{16} bit 25 to indicate that the installation has the capability to provide data in Register 20_{16}.

e. As an Option, Register 18_{16} bit 24 to indicate that the installation has the capability to provide data in Register 21_{16}.

Note 3: *Although not a function of Elementary Surveillance, Register 18_{16} bit 9 is set when the transponder is interfaced with TCAS to indicate that the TCAS Active Resolution Advisory Register 30_{16} is supported.*

Note 4: *Elementary Surveillance only requires that Register 18_{16} be serviced. Therefore, if no other transponder functions require the servicing of Register 19_{16} through $1C_{16}$, these Registers will be set to ALL ZERO.*

2.2.24.5.2 Data Requirements

2.2.24.5.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16}

a. Register 18_{16} bit 41 **shall** be set to ONE (1) if the transponder is required to service any part of Register 10_{16}.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 10_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 10_{16}.*

b. Once Register 18_{16} bit 41 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) until power-off of the transponder.

2.2.24.5.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16}

a. Register 18_{16} bit 34 **shall** be set to ONE (1) if the transponder is required to service any part of Register 17_{16} as provided in §2.2.24.4.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 17_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 17_{16}.*

b. Once Register 18_{16} bit 34 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 18_{16} bit 34 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 17_{16} as provided in §2.2.24.4.

2.2.24.5.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16}

a. Register 18_{16} bit 33 **shall** be set to ONE (1) if the transponder is required to service any part of Register 18_{16}.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 18_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 18_{16}.*

b. Once Register 18_{16} bit 33 has been set to ONE (1) during a particular power-on cycle, then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 18_{16} bit 33 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 18_{16}.

2.2.24.5.2.4 Required Servicing of Register 18_{16} Associated with Register 20_{16}

a. Register 18_{16} bit 25 **shall** be set to ONE (1) if the transponder has received either Aircraft Identification (also referred to as Flight Identification as specified in the Flight Plan) or Aircraft Registration data in the Aircraft Installation since the power-on of the transponder.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 20_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 20_{16}.*

b. Once Register 18_{16} bit 25 has been set to ONE (1), then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 18_{16} bit 25 **shall** be set to ZERO (0) if the transponder has received no data from the Aircraft installation that could be used to properly service Register 20_{16} since power-on of the transponder.

2.2.24.5.2.5 Required Servicing of Register 18_{16} Associated with Optional Register 21_{16}

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs need to be complied with.*

a. Register 18_{16} bit 24 **shall** be set to ONE (1) if the transponder has received Aircraft Registration data in the Aircraft Installation since power-on of the transponder.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 21_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 21_{16}.*

b. Once Register 18_{16} bit 24 has been set to ONE (1), then it shall remain set to ONE (1) until power-off of the transponder.

c. Register 18_{16} bit 24 shall be set to ZERO (0) if the transponder has received no data from the Aircraft installation that could be used to properly service Register 21_{16} since power-on of the transponder.

2.2.24.5.3 Maximum Update Interval of Register 18_{16} to $1C_{16}$

a. The maximum update interval at which Register 18_{16} (and/or Register 19_{16} to $1C_{16}$ if implemented) **shall** be reloaded with valid data is 5.0 seconds, i.e., Register 18_{16} (and/or Register 19_{16} to $1C_{16}$ if implemented) **shall** be updated at least once every 5.0 seconds.

b. The time between availability of data that causes a change in Register 18_{16} (and/or Register 19_{16} to $1C_{16}$ if implemented) and the time that the change is made to Register 18_{16} (and/or Register 19_{16} to $1C_{16}$ if implemented) **shall** be less than the maximum update interval specified as 5.0 seconds.

c. The setting of bits in Register 18_{16} to $1C_{16}$ is static. If a bit has been set to ONE (1) in one of these registers since power-on of the transponder, then the bit **shall** remain set to ONE (1) until power-off of the transponder.

2.2.24.6 Register 20_{16} -- Aircraft Identification and Data Sources

2.2.24.6.1 Purpose and Definition

The Mode-S transponder shall format Register 20_{16} as defined in Appendix B, Table B-3-32 and associated notes.

Note 1: *ICAO Annex 10, Volume IV requires that the aircraft identification to be used is that employed in the flight plan. When no flight plan is available, the registration marking is used if available, otherwise the aircraft identification is set to ALL ZERO's.*

Note 2: *On aircraft, it is possible to have access to data from an interface where the pilot can enter the data that is employed in the flight plan. This could be the telephony designator of the aircraft operating agency, followed by the flight identification or the registration marking of the aircraft. This piece of information is considered as variable data and the transponder cannot know what is really entered by the pilot (depending on operational procedure). This piece of information is named "Flight Identification" within the rest of this section. In ARINC, it is normally provided via ARINC Labels 233 through 237 or by Label 360 for block transfer data.*

In addition on some platforms it is also possible to receive another piece of data which is the registration marking (tail number). This is considered as a fixed data which does not vary during the flight. This piece of information can only be used when there is no data coming from the interface delivering the variable data. This is referenced as "Aircraft Registration´ within the rest of this section.

2.2.24.6.2 Register 20_{16} -- Data Requirements

2.2.24.6.2.1 Data Selection Priority

Use of Flight Identification or Aircraft Registration Data in Register 20_{16} **shall** comply with the following guidelines:

a. If Flight Identification data is available at anytime during unit operation, then flight identification data **shall** be inserted into the character subfields of Register 20_{16}.

   Note: *Flight Identification data is normally provided via ARINC Labels 233 through 237 or by Label 360 for block transfer data. Available data means that the status of the data is not set to No Computed Data (NCD).*

b. If Flight Identification data is NOT available then Aircraft Registration, if available, **shall** be inserted into the character subfields of Register 20_{16}.

   Note: *If the transponder has no input from the Aircraft installation that could be used to service Register 20_{16}, then the Register 20_{16} Character subfields are set to ZERO (0) and Register 10_{16} (Data Link Capability Report) bit 33 is set to ZERO (0).*

c. If Flight Identification data has been entered into Register 20_{16} and then becomes NOT available, then the character subfields of the registers **shall** be set to all ZERO's.

d. In all of the above cases, encoding of the character subfields in Register 20_{16} **shall** conform to the following:

   (1). All characters will be left justified prior to encoding the Character fields.

   (2). Characters will be coded consecutively without intervening SPACE codes.

   (3). Any unused character spaces at the end of the subfield should contain a SPACE character code.

   (4). Any extra characters shall be truncated.

2.2.24.6.3 Register 20_{16} – Flight Identification Update Rates

a. The maximum update interval at which Register 20_{16} **shall** be reloaded with valid data is 5.0 seconds.

   Note: *Effectively, Register 20_{16} must be updated every 5.0 seconds or sooner.*

b. If Register 20_{16} cannot be updated within a 10.0 second timeframe (e.g., twice the specified maximum update interval of 5.0 seconds), then:

   (1). The contents of the character field of Register 20_{16} **shall** be set to ZERO (0).

   (2). Bit 7 of Register 17_{16} **shall** be set to ZERO (0).

   (3). Bit 33 of Register 10_{16} **shall** be set to ZERO (0). (see §2.2.24.3.2.4.)

   (4). Bit 25 of Register 18_{16} **shall not** change state if Register 20_{16} has been properly serviced during the power-on cycle. If Register 20_{16} has not been properly serviced during the power-on cycle, then bit 25 of Register 18_{16} must be verified as being set to ZERO (0) (see §2.2.24.5.1 and §2.2.24.5.2.4).

c. The time between availability of data that causes a change in Register 20_{16} and the time that the change is made to Register 20_{16} **shall** be less than the maximum update interval specified as 5.0 seconds.

Note: *The time between establishing availability of data and the time of updating Register 20_{16} should be minimized (e.g., data latency should be minimized).*

2.2.24.6.4 Aircraft Identification Declaration of Capability

Aircraft Identification Capability of the transponder **shall** be declared as provided in the following subsections.

2.2.24.6.4.1 In Register 10_{16} – Data Link Capability Report

Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 10_{16} via bit 33 as defined in §2.2.24.3.2.4.

2.2.24.6.4.2 In Register 17_{16} – Common Usage GICB Capability Report

Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 17_{16} via bit 7 as defined in §2.2.24.4.2.1.

2.2.24.6.4.3 In Register 18_{16} – Mode S Specific Services Capability Report

Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 18_{16} via bit 25 as defined in §2.2.24.5.2.4.

2.2.24.6.5 Flight Identification Change Reporting

If the aircraft identification reported in the "AIS" subfield is changed, then the transponder **shall** report the new aircraft identification in accordance with §2.2.19.1.13.e by use of the Comm-B Broadcast Message protocol (see §2.2.19.1.12.5).

2.2.24.7 Register 21_{16} – Aircraft Registration (Optional)

Note: *Elementary Surveillance does not require that Register 21_{16} be serviced. However, if Register 21_{16} is serviced, the following subparagraphs need to be complied with.*

2.2.24.7.1 Purpose and Definition

The Mode-S transponder shall format Register 21_{16} as defined in Appendix B, Table B-3-33 and associated notes.

2.2.24.7.2 Register 21_{16} – Data Requirements

a. If valid Aircraft Registration data is available, then the data **shall** be used to fill the Characters in Register 21_{16}, "Aircraft and Airline Registration Markings" as shown in Appendix B, Table B-3-33.

Note: *Aircraft Registration data is normally provided via ARINC Labels 301 through 303 or by Label 360 for block transfer data. Available data means that the status of the data is not set to No Computed Data (NCD).*

b. There is currently no method to provide the transponder with ICAO Airline Registration marking. Therefore, bits 44 through 56 of Register 21_{16} **shall** be set to ZERO (0).

c. When Register 21_{16} is being serviced with Aircraft Registration data, then Register 21_{16} **shall** be available for GICB Extraction as per §2.2.24.1.

2.2.24.7.3 Register 21_{16} – Update Rates

a. The maximum update interval at which Register 21_{16} **shall** be reloaded with valid data is 15.0 seconds.

Note: *Register 21_{16} is updated every 15.0 seconds or sooner.*

b. If Register 21_{16} cannot be updated within a 30.0 second timeframe (e.g., twice the specified maximum update interval of 15.0 seconds), then the contents of Register 21_{16} **shall** be set to ZERO (0), and:

(1). Bit 24 of Register 18_{16} **shall not** change state if Register 21_{16} has been properly serviced since power-on of the transponder. If Register 21_{16} has not been properly serviced since power-on of the transponder, then bit 24 of Register 18_{16} must be verified as being set to ZERO (0).

c. The time between availability of data that causes a change in Register 21_{16} and the time that the change is made to Register 21_{16} **shall** be less than the maximum update interval specified as 15.0 seconds.

Note: *The time between establishing availability of data and the time of updating Register 21_{16} should be minimized (e.g., data latency should be minimized).*

2.2.24.7.4 Register 21_{16} – Declaration of Capability

2.2.24.7.4.1 In Register 17_{16} – Common Usage GICB Capability Report

Correct servicing of at least one field in Register 21_{16} **shall** be reported in Register 17_{16} via bit 8 as defined in §2.2.24.4.2.2.

2.2.24.7.4.2 In Register 18_{16} –Mode S Specific Services Capability Report

Correct servicing of at least one field in Register 21_{16} **shall** be reported in Register 18_{16} via bit 24 as defined in §2.2.24.5.2.5.

2.2.25 Enhanced Surveillance (EHS) Compliant Transponders

This section contains requirements on Mode S transponders required to support Enhanced Surveillance (EHS).

The Enhanced Surveillance application entails the use of the following Downlink Aircraft Parameters (DAPs):

a. Magnetic Heading

b. Indicated Airspeed and/or Mach No.

c. Vertical Rate (climb/descend)

d. MCP/FCU Selected Altitude

e. Ground Speed

f. Roll Angle

g. Track Angle Rate (or True Airspeed if Track Angle Rate is not available)

h. True Track Angle

i. Barometric Pressure Setting

These DAPS are embedded in three transponder Registers (40_{16}, 50_{16}, and 60_{16}).

In addition to those three Registers, the Enhanced Surveillance application uses a number of capability report Registers to assess the real time ability of the aircraft to transmit DAPs. The format requirements related to the Enhanced Surveillance application for these capability registers are defined in §2.2.25.1 through §2.2.25.4.

The Enhanced Surveillance application presents the following benefits:

a. The provision of actual aircraft derived data, such as Magnetic Heading, Air Speed, Selected Altitude and Vertical Rate, enables controllers to reduce the radio telephony (RT) workload and better assess the separation situations.

b. EHS enables Monitoring Tools and Safety Nets, which work on actual data, to be implemented or improved (e.g., Short Term Conflict Alert) which, in turn, will allow safety levels to be maintained or improved despite the increase in traffic levels.

Transponder capable of supporting EHS must:

a. Support ELS as defined in §2.2.24.

b. At least be able to provide data in Registers 40_{16}, 50_{16}, and 60_{16}.

c. Support capability reporting in CA and Registers 10_{16} to $1F_{16}$.

Note 1: *Servicing Register $5F_{16}$ is not mandatory.*

Note 2: *For the remaining subsections of this section, servicing of a field or subfield in a register implies that valid data has been received at a sufficient rate to meet the update requirements specified for the given register in Appendix B.*

2.2.25.1 Register 10_{16} – Data Link Capability Report

2.2.25.1.1 Purpose and Definition

Register 10_{16} **shall** be formatted as specified in Appendix B Table B-3-16.

Note: *The following paragraphs detail the minimum requirement for Enhanced Surveillance. The other fields need to be managed according to the additional capabilities supported by the transponder.*

2.2.25.1.2 Data Requirements

2.2.25.1.2.1 Bits 1 to 8, BDS Code

Bits 1 through 8 of Register 10_{16} are defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.1.

2.2.25.1.2.2 Bits 17 to 23, Mode S Subnetwork Version Number

Bit 17 through 23 (Mode S Subnetwork Version) of Register 10_{16} are defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.2.

2.2.25.1.2.3 Bit 25, Mode S Specific Services Capability

a. Register 10_{16} (Data Link Capability Report) bit 25 **shall** be set to ONE (1) if the transponder is receiving any data from the Aircraft installation with which to service Registers $1D_{16}$ through $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional) or 60_{16} (or other registers) as provided in the respective sections for each register in this document.

   Note 1: *Registers $1D_{16}$ through $1F_{16}$ are included above in order to provide for possible declaration of capability to provide Dataflash or other Mode Specific Protocol capability.*

   Note 2: *This requirement is not established by the transponder LRU own capability to service Registers $1D_{16}$ through $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional) or 60_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Registers $1D_{16}$ through $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional) or 60_{16}.*

b. Register 10_{16} (Data Link Capability Report) bit 25 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service either Registers $1D_{16}$ through $1F_{16}$, 40_{16}, 50_{16}, $5F_{16}$ (Optional), 60_{16} or any other Registers other than 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} through $1C_{16}$, 20_{16} and 30_{16}.

c. When bit 25 is set to ONE (1), it **shall** indicate that at least one Mode S Specific Service is supported.

   Note: *Mode S Specific Service refers to the servicing of Registers other than GICB services related to Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} through $1C_{16}$, 20_{16} and 30_{16}.*

2.2.25.1.2.4 Bit 35, Surveillance Identifier Code (SI)

Bit 35 of Register 10_{16} is set to ONE (1) as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.5.

2.2.25.1.2.5 Bit 36, Common Usage GICB Capability Report

Bit 36 of Register 10_{16} is managed as specified in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.3.2.6.

2.2.25.1.3 Maximum Update Interval of Register 10_{16}

a. The maximum update interval at which Register 10_{16} **shall** be reloaded with valid data is ≤ 4.0 seconds.

Note: *Effectively, Register 10_{16} must be updated every 4.0 seconds or sooner.*

b. Register 10_{16} **shall** be updated within one second of the data changing and at least every four seconds thereafter.

c. If a particular data field in Register 10_{16} cannot be updated within 8.0 seconds (e.g., twice the specified maximum update interval of ≤ 4.0 seconds), then the status bit (if specified for that field) **shall** indicate that the data in that field is invalid and the data field shall be ZEROed.

2.2.25.1.4 Change Reporting

When Register 10_{16} is changed, then the Register **shall** be broadcast as described in §2.2.19.1.12.6.3.

2.2.25.2 Register 17_{16}—Common Usage GICB Capability Report

2.2.25.2.1 Register 17_{16} – Purpose and Definition

The Mode-S transponder **shall** format Register 17_{16} as defined in Appendix B, Table B-3-23 and associated notes.

The Enhanced Surveillance (EHS) Compliant Transponder manages the following bits in Register 17_{16}.

a. Bit 7 to indicate servicing of Register 20_{16} Aircraft Identification as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.4.2.1.

b. Bit 8 to indicate servicing of Optional Register 21_{16} Aircraft Registration as defined in Elementary Surveillance (ELS) Compliant Transponder §2.2.24.4.2.2.

c. Bit 9 to indicate whether the aircraft installation is servicing any part of Register 40_{16} as defined in §2.2.25.2.2.3.

d. Bit 16 to indicate whether the aircraft installation is servicing any part of Register 50_{16} as defined in §2.2.25.2.2.4.

e. Bit 24 to indicate whether the aircraft installation is servicing any part of Register 60_{16} as defined in §2.2.25.2.2.6.

2.2.25.2.2 Enhanced Surveillance (EHS) Servicing Requirements

2.2.25.2.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16}

Refer to §2.2.24.4.2.1 where requirements have previously been provided for servicing Register 20_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.2.2.2 Required Servicing of Register 17_{16} Associated with Optional Register 21_{16}

Refer to §2.2.24.4.2.2 where requirements have previously been provided for servicing Register 21_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.2.2.3 Required Servicing of Register 17_{16} Associated with Register 40_{16}

a. Register 17_{16} bit 9 **shall** be set to ONE (1) if the transponder is servicing either MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, FMS Vertical Mode (MCP/FCU Mode Bits), or Target Altitude Source data in Register 40_{16}.

   Note 1: *This requirement is not established by the transponder LRU own capability to service Register 40_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 40_{16}.*

   Note 2: *FMS Vertical Mode data refers to data used to establish bits 48 through 51 of Register 40_{16}.*

   Note 3: *Target Altitude Source data refers to data used to establish bits 54 through 56 of Register 40_{16}.*

b. Register 17_{16} bit 9 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 40_{16}.

2.2.25.2.2.4 Required Servicing of Register 17_{16} Associated with Register 50_{16}

a. Register 17_{16} bit 16 **shall** be set to ONE (1) if the transponder is servicing either Roll Angle, True Track Angle, Ground Speed, Track Angle Rate, or True Airspeed data in Register 50_{16}.

   Note: *This requirement is not established by the transponder LRU own capability to service Register 50_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 50_{16}.*

b. Register 17_{16} bit 16 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 50_{16}.

2.2.25.2.2.5 Required Servicing of Register 17_{16} Associated with Optional Register $5F_{16}$

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ is implicitly required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, if Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

a. Register 17_{16} bit 23 shall be set to ONE (1) if the transponder is receiving MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, or FMS Vertical Mode (MCP/FCU Mode Bits) necessary to update Register 40_{16} (see §2.2.25.5) which then requires that Register $5F_{16}$ be updated in accordance with §2.2.25.7.

Note: *This requirement is not established by the transponder LRU own capability to service Register $5F_{16}$. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register $5F_{16}$.*

b. Register 17_{16} bit 23 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register $5F_{16}$.

2.2.25.2.2.6 Required Servicing of Register 17_{16} Associated with Register 60_{16}

a. Register 17_{16} bit 24 **shall** be set to ONE (1) if the transponder is servicing either Magnetic Heading, Indicated Airspeed, Mach, Barometric Altitude Rate, or Inertial Vertical Velocity data in Register 60_{16}.

Note: *This requirement is not established by the transponder LRU own capability to service Register 60_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 60_{16}.*

b. Register 17_{16} bit 24 **shall** be set to ZERO (0) if the transponder is receiving no data from the Aircraft installation that could be used to properly service Register 60_{16}.

2.2.25.2.2.7 Maximum Update Interval of Register 17_{16}

a. The maximum update interval at which Register 17_{16} **shall** be reloaded with valid data is 5.0 seconds.

Note: *Effectively, Register 17_{16} must be updated at least once every 5.0 seconds.*

b. The time between availability of data that causes a change in Register 17_{16} and the time that the change is made to Register 17_{16} **shall** be less than the maximum update interval specified as 5.0 seconds.

c. If a particular data field in Register 17_{16} cannot be updated within 10.0 seconds (e.g., twice the specified maximum update interval of 5.0 seconds), then the status bit (if specified for that field) **shall** indicate that the data in that field is invalid and the data field shall be ZEROed.

2.2.25.2.3 Change Reporting

When Register 17_{16} is changed, bit 36 of Register 10_{16} is to be toggled as defined in §2.2.24.3.2.6.

2.2.25.3 Register 18 through $1C_{16}$ Mode S Specific Services GICB Capability

2.2.25.3.1 Purpose and Definition

The Mode-S transponder **shall** format Registers 18_{16} through $1C_{16}$ as defined in Appendix B, Table B-3-24 through Table B-3-28 and associated notes for Register 18_{16} through $1C_{16}$, respectively.

Note 1: *Registers 18_{16} to $1C_{16}$ are used to indicate the capability of the aircraft installation to provide data for each register i.e., the Register or a part of the Register is managed by the transponder, and it is known that data can be received from the installation to fill this field.*

Note 2: *This is not established by the Transponder LRU own capability. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to service the corresponding register. Once this capability is established it remains set until power-off of the transponder.*

Transponders that support Enhanced Surveillance (EHS) functions manage Register 18_{16} as follows:

a. Register 18_{16} bit 41 to indicate that the installation has the capability to provide data in Register 10_{16}.

b. Register 18_{16} bit 34 to indicate that the installation has the capability to provide data in Register 17_{16}.

c. Register 18_{16} bit 33 to indicate that the installation has the capability to provide data in Register 18_{16}.

d. Register 18_{16} bit 32 to indicate that the installation has the capability to provide data in Register 19_{16}.

e. Register 18_{16} bit 25 to indicate that the installation has the capability to provide data in Register 20_{16}.

f. Register 18_{16} bit 24 to indicate that the installation has the capability to provide data in Register 21_{16} (Optional).

g. Register 19_{16} bit 49 to indicate that the installation has the capability to provide data in Register 40_{16}.

h. Register 19_{16} bit 33 to indicate that the installation has the capability to provide data in Register 50_{16}.

i. Register 19_{16} bit 18 to indicate that the installation has the capability to provide data in Register $5F_{16}$ (Optional).

j Register 19_{16} bit 17 to indicate that the installation has the capability to provide data in Register 60_{16}.

Note 3: *Although not a function of Elementary Surveillance, Register 18_{16} bit 9 is set when the transponder is interfaced with TCAS to indicate that the TCAS Active Resolution Advisory Register 30_{16} is supported.*

Note 4: *Combined Elementary and Enhanced Surveillance only require that Register 18_{16} and 19_{16} be serviced; Therefore, if no other transponder functions require the servicing of Register $1A_{16}$ through $1C_{16}$, these registers will be set to ALL ZERO.*

2.2.25.3.2 Enhanced Surveillance Capability Requirements

2.2.25.3.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16}

Refer to §2.2.24.5.2.1 where requirements have previously been provided for servicing Register 10_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16}

Refer to §2.2.24.5.2.2 where requirements have previously been provided for servicing Register 17_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16}

Refer to §2.2.24.5.2.3 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.4 Required Servicing of Register 18_{16} Associated with Register 19_{16}

a. Register 18_{16} bit 32 **shall** be set to ONE (1) if the transponder is required to service any part of Register 19_{16} as provided in §2.2.25.3.2.7 through §2.2.25.3.2.10.

   Note: *This requirement is not established by the Transponder LRU own capability to service Register 19_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register 19_{16}.*

b. Once Register 18_{16} bit 32 has been set to ONE (1) since power-on of the transponder, then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 18_{16} bit 32 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register 19_{16} as provided in §2.2.25.3.2.7 through §2.2.25.3.2.9.

2.2.25.3.2.5 Required Servicing of Register 18_{16} Associated with Register 20_{16}

Refer to §2.2.24.5.2.4 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.6 Required Servicing of Register 18_{16} Associated with Register 21_{16} (Optional)

Refer to §2.2.24.5.2.5 where requirements have previously been provided for servicing Register 18_{16} as part of the Elementary Surveillance (ELS) Compliant Transponder.

2.2.25.3.2.7 Required Servicing of Register 19_{16} Associated with Register 40_{16}

a. Register 19_{16} bit 49 shall be set to ONE (1) if the transponder has received either MCP/FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, FMS Vertical Mode (MCP/FCU Mode Bits), or Target Altitude Source data in the Aircraft Installation during the power-on cycle.

(Refer to Appendix B, Table B-3-64 for full definition of Register 40_{16}).

Note 1: *This requirement is not established by the Transponder LRU own capability to service Register 40_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 40_{16}.*

Note 2: *FMS Vertical Mode data refers to data used to establish bits 48 through 51 of Register 40_{16}.*

Note 3: *Target Altitude Source data refers to data used to establish bits 54 through 56 of Register 40_{16}.*

b. Once Register 19_{16} bit 49 has been set to ONE (1) since power-on of the transponder, then it shall remain set to ONE (1) until power-off of the transponder.

c. Register 19_{16} bit 49 shall be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 40_{16} during the power-on cycle.

2.2.25.3.2.8 Required Servicing of Register 19_{16} Associated with Register 50_{16}

a. Register 19_{16} bit 33 **shall** be set to ONE (1) if the transponder has received either Roll Angle, True Track Angle, Ground Speed, Track Angle Rate, or True Airspeed data in the Aircraft installation during the power-on cycle.

(Refer to Appendix B, Table B-3-80 for full definition of Register 50_{16})

Note: *This requirement is not established by the Transponder LRU own capability to service Register 50_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 50_{16}.*

b. Once Register 19_{16} bit 33 has been set to ONE (1) since power-on of the transponder, then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 19_{16} bit 33 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 50_{16} since power-on of the transponder.

2.2.25.3.2.9 Required Servicing of Register 19_{16} Associated with Optional Register $5F_{16}$

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ is implicitly required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, if Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

a. Register 19_{16} bit 18 shall be set to ONE (1) if the transponder is required to service any part of Register $5F_{16}$ as provided in §2.2.25.7.

Note: *This requirement is not established by the Transponder LRU own capability to service Register $5F_{16}$. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data of which processing would result in the need to update Register $5F_{16}$.*

b. Once Register 19_{16} bit 18 has been set to ONE (1) since power-on of the transponder, then it shall remain set to ONE (1) until power-off of the transponder.

c. Register 19_{16} bit 18 shall be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could result in the need to service Register $5F_{16}$ as provided in §2.2.25.7.

2.2.25.3.2.10 Required Servicing of Register 19_{16} Associated with Register 60_{16}

a. Register 19_{16} bit 17 shall be set to ONE (1) if the transponder has received either Magnetic Heading, Indicated Airspeed, Mach, Barometric Altitude Rate, or Inertial Vertical Velocity data in the Aircraft installation during the power-on cycle.

Refer to Appendix B, Table B-3-96 for full definition of Register 60_{16}.

Note: *This requirement is not established by the Transponder LRU own capability to service Register 60_{16}. Rather, it is established by the Aircraft installation capability to provide the transponder with the appropriate data with which to then service Register 60_{16}.*

b. Once Register 19_{16} bit 17 has been set to ONE (1) since power-on of the transponder, then it **shall** remain set to ONE (1) until power-off of the transponder.

c. Register 19_{16} bit 17 **shall** be set to ZERO (0) if the transponder receives no data from the Aircraft installation that could be used to properly service Register 60_{16} since power-on of the transponder.

2.2.25.3.3 Maximum Update Interval of Registers 18_{16} to $1C_{16}$

a. The maximum update interval at which Register 18_{16} and/or Register 19_{16} **shall** be reloaded with valid data is 5.0 seconds.

Note: *Effectively, Register 18_{16} and/or Register 19_{16} are updated at least once every 5.0 seconds.*

b. The time between availability of data that causes a change in Register 18_{16} and/or Register 19_{16} and the time that the change is made to Register 18_{16} and/or Register 19_{16} **shall** be less than the maximum update interval specified as 5.0 seconds.

c. The setting of bits in Register 18_{16} to $1C_{16}$ is static. If a bit has been set to ONE (1) in one of these Registers since power-on of the transponder, then the bit **shall** remain set to ONE (1) until power-off of the transponder.

2.2.25.4 Register $1D_{16}$ to $1F_{16}$ Mode S Specific Services MSP Capability

a. Register $1D_{16}$ to $1F_{16}$ **shall** be formatted as specified in Appendix B Table B-3-29 to B-3-31.

b. Although, servicing of Register $1D_{16}$ through $1F_{16}$ is not required by Enhanced Surveillance, the “MB” field of these registers **shall** be set to ALL ZEROs.

Note: *There is no formal requirement to implement data-flash however Mode S ground station may systematically extract Register $1D_{16}$ to decide to extract a Register using GICB protocol or using the data-flash application.*

2.2.25.5 Register 40_{16} – Selected Vertical Intention

2.2.25.5.1 Purpose and Definition

a) Transponders **shall** format Register 40_{16} as defined in Appendix B, Table B-3-64.

b) The transponder **shall** comply with all constraints and requirements for servicing Register 40_{16} that are provided with Table B-3-64 in Appendix B.

2.2.25.5.2 Data Requirements

2.2.25.5.2.1 Selected Altitude from Altitude Control Panel

a. The transponder **shall** process Selected Altitude From Altitude Control Panel (Mode Control Panel/Flight Control Unit or equivalent equipment) data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table and format the data into bits 2 through 13 of the Register 40_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 through 13.

d. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 through 13.

e. Bits 2 through 13 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.5.2.2 FMS Selected Altitude

a. The transponder **shall** process FMS Selected Altitude data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table and format the data into bits 15 through 26 of the Register 40_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 14 **shall** be set to ONE (1) whenever valid FMS Selected Altitude data is available in bits 15 through 26.

d. If FMS Selected Altitude data is not available for insertion into bits 15 through 26, Status Bit 14 **shall** be set to ZERO (0).

e. If FMS Selected Altitude data is not available for insertion into bits 15 through 26, bits 15 through 26 **shall** be set to ZERO (0).

2.2.25.5.2.3 Barometric Pressure Setting

a. The transponder **shall** process Barometric Pressure Setting data from on-board aircraft data sources as provided in Appendix B, Table B-3-64 of the Register 40_{16} definition table. Further processing of the input Barometric Pressure Setting data is needed as follows:

(1). Note that the Barometric Pressure Setting data received may be in BCD format and must be converted to Binary format prior to encoding data into Register 40_{16}. Tentative information regarding BCD to Binary Conversion and final mapping of the data into Register 40_{16} is provided in the following note:

Note: *Barometric Pressure Setting BCD to BINARY Conversion Method Consider an input of 1085.9 millibars in BCD data.*

Multiply by 10 to give the BCD count of 0.1 increments needed to represent the input data.

Yields: 10859

10859/2	=	*5429*	-	*1*							
5429/2	=	*2714*	-	*1*							
2714/2	=	*1357*	-	*0*							
1357/2	=	*678*	-	*1*							
678/2	=	*339*	-	*0*							
339/2	=	*169*	-	*1*							
169/2	=	*84*	-	*1*							
84/2	=	*42*	-	*0*							
42/2	=	*21*	-	*0*							
21/2	=	*10*	-	*1*							
10/2	=	*5*	-	*0*							
5/2	=	*2*	-	*1*							
2/2	=	*1*	-	*0*							
½	=	*0*	-	*1*	==	*0010 1010 0110 1011 HEX*	==	*2A6B HEX*	==	*10859 Decimal*	

Start:	*0001*	*0000*	*1000*	*0101*	*1001*		*10859*	*BCD*
Rotate R:	*0000*	*1000*	*0100*	*0010*	*1100*	*1*		
Add	*0000*	*1101*	*0000*	*0000*	*1101*			*Add "0D" Hex to each nibble that has the*
	0000	*0101*	*0100*	*0010*	*1001*		*05429*	*MSB of the nibble set to "1". Disregard the Carry*
Rotate R:	*0000*	*0010*	*1010*	*0001*	*0100*	*1*		
Add	*0000*	*0000*	*1101*	*0000*	*0000*			
	0000	*0010*	*0111*	*00001*	*0100*		*02714*	
Rotate R:	*0000*	*0001*	*0011*	*1000*	*1010*	*0*		
Add	*0000*	*0000*	*0000*	*1101*	*1101*			
	0000	*0001*	*0011*	*0101*	*0111*		*01357*	
Rotate R:	*0000*	*0000*	*1001*	*1010*	*1011*	*1*		
Add	*0000*	*0000*	*1101*	*1101*	*1101*			
	0000	*0000*	*0110*	*0111*	*1000*		*00678*	
Rotate R:	*0000*	*0000*	*0011*	*0011*	*1100*	*0*		
Add	*0000*	*0000*	*0000*	*0000*	*1101*			
	0000	*0000*	*0011*	*0011*	*1001*		*00339*	
Rotate R:	*0000*	*0000*	*0001*	*1001*	*1100*	*1*		
Add	*0000*	*0000*	*0000*	*1101*	*1101*			
	0000	*0000*	*0001*	*0110*	*1001*		*00169*	
Rotate R:	*0000*	*0000*	*0000*	*1011*	*0100*	*1*		
Add	*0000*	*0000*	*0000*	*1101*	*0000*			
	0000	*0000*	*0000*	*1000*	*0100*		*00084*	
Rotate R:	*0000*	*0000*	*0000*	*0100*	*0010*	*0*	*00042*	
Rotate R:	*0000*	*0000*	*0000*	*0010*	*0001*	*0*	*00021*	
Rotate R:	*0000*	*0000*	*0000*	*0001*	*0000*	*1*	*00010*	
Rotate R:	*0000*	*0000*	*0000*	*0000*	*1000*			
Add	*0000*	*0000*	*0000*	*0000*	*1101*			
	0000	*0000*	*0000*	*0000*	*0101*		*00005*	
Rotate R:	*0000*	*0000*	*0000*	*0000*	*0010*	*1*	*00002*	
Rotate R:	*0000*	*0000*	*0000*	*0000*	*00001*	*0*	*00001*	
Rotate R:	*0000*	*0000*	*0000*	*0000*	*0000*	*1*	*00000*	

Binary Equivalent == 0010 1010 0110 1011 = 2A6B Hex = 10859 Decimal

Next:

Establish Equivalent of 800.0 millibars having 0.1 resolution
Effectively, establish a count of 8000 millibars in binary: The value is 1F40 Hex
Establish 2's Complement of 1F40 Hex as E0C0 Hex.
Now, effectively subtract 8000 from the Binary Equivalent above as follows:
Binary Equivalent = 0010 1010 0110 101 = 2A6B Hex = 10859 Decimal
Add Neg. 800.0 mb = 1110 0000 1100 0000 = E0C0 Hex = -8000 millibars
Resultant Sum: = 0000 1011 0010 1011 = 0B2B Hex = 2859 Decimal

Map the Resultant Data into Bits 28 through 39 of Register 40_{16} as follows:

	MSB											**LSB**
Bit:	28	29	30	31	32	33	34	35	36	37	38	39
Data:	1	0	1	1	0	0	1	0	1	0	1	1

(2). Note that the encoding that is provided in Appendix B, Table B-3-64 Register 40_{16} for Barometric Pressure Setting represents the input Barometric Pressure Setting data MINUS 800 millibars (mb). See Appendix B, Table B-3-64, Register 40_{16} definition. Also, note that this 800 millibar correction has been taken into account in the BCD to BINARY conversion performed in the Note given in §2.2.25.5.2.3.a.(1).

b. The data loaded into the "MB" field **shall** be the Barometric Pressure Setting MINUS 800 millibars (mb) that has been converted to BINARY data in a manner that is consistent and equivalent with the BCD to BINARY conversion performed in the Note given in §2.2.25.5.2.3.a.(1).

c. Status Bit 27 **shall** be set to ONE (1) whenever valid data is available in bits 28 through 39, and the conditions given in §2.2.25.5.2.3.d are not applicable.

d. Status Bit 27 **shall** be set to ZERO (0) whenever:

(1). There is no valid data with which to fill bits 28 through 39.

(2). The input Barometric Pressure Setting data is less than 800 millibars (mb).

Note: *This would result in a negative Barometric Pressure Setting after subtracting 800 millibars (mb) and doing the BCD to BINARY conversion.*

(3). The input Barometric Pressure Setting data is greater than 1209.5 millibars (mb).

e. Bits 28 through 39 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.5.2.4 FMS Vertical Mode Bits

Note: *FMS Vertical Mode bits refer to bits 48 through 51 of Register 40_{16}.*

2.2.25.5.2.4.1 Status of MCP / FCU Mode Bits (Bit 48)

Bit 48 **shall** indicate whether the mode bits (49, 50, and 51) are actively being populated (e.g., set) in Register 40_{16} in accordance with the following table:

Table 2-5: Status of MCP/FCU Mode Bits (Bit 48) Encoding

Bit 48	Meaning
0	No Mode Information Provided
1	Mode Information Deliberately Provided

Essentially, if information is provided to the transponder to set either bit 49, 50, or 51 to either "0" or "1," then bit 48 **shall** be set to ONE (1) Otherwise, bit 48 **shall** be set to ZERO (0).

2.2.25.5.2.4.2 Vertical Navigation Mode (Bit 49)

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Vertical Navigation Mode is active.

b. The transponder **shall** set bit 49 in accordance with the following table:

Table 2-6: Vertical Navigation Mode (Bit 49) Encoding

Bit 49	Meaning
0	VNAV Not Active
1	VNAV Active

c. If appropriate information is not available to indicate whether or not the Vertical Navigation Mode is active, then the transponder **shall** set bit 49 to ZERO (0).

2.2.25.5.2.4.3 Altitude Hold Bit

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Altitude Hold Mode is active.

b. The transponder **shall** set bit 50 in accordance with the following table:

Table 2-7: Altitude Hold Mode (Bit 50) Encoding

Bit 50	Meaning
0	Altitude Hold Not Active
1	Altitude Hold Active

c. If appropriate information is not available to indicate whether or not the Altitude Hold Mode is active, then the transponder **shall** set bit 50 to ZERO (0).

2.2.25.5.2.4.4 Approach Mode Bit (Bit 51)

a. The transponder **shall** accept information from an appropriate interface that indicates whether or not the Approach Mode is active.

b. The transponder **shall** set bit 51 in accordance to the following:

Table 2-8: Approach Mode (Bit 51) Encoding

Bit 51	Meaning
0	Approach Mode Not Active
1	Approach Mode Active

c. If appropriate information is not available to indicate whether or not the Approach Mode is active, then the transponder **shall** set bit 51 to ZERO (0).

2.2.25.5.2.5 Reserved Bits (Bits 40 to 47, 52 and 53)

Bits 40 to 47, 52 and 53 of Register 40_{16} “MB” field **shall** be set to ZERO (0).

2.2.25.5.2.6 Target Altitude Bits

2.2.25.5.2.6.1 Status of Target Altitude Source Bits (Bit 54)

Bit 54 **shall** indicate whether the Target Altitude Source bits (55 and 56) are actively being populated (e.g., set) in Register 40_{16} in accordance with the following table:

Table 2-9: Status of Target Altitude Source Bits (Bit 54) Encoding

Bit 54	Meaning
0	No Source Information Provided
1	Source Information Deliberately Provided

Essentially, if information is provided to the transponder to set either bit 55 or 56 (or both) to either “0” or “1”, then bit 54 **shall** be set to ONE (1). Otherwise, bit 54 **shall** be set to ZERO (0).

2.2.25.5.2.6.2 Target Altitude Source Bits (Bits 55 & 56)

a. The transponder **shall** accept information from an appropriate interface that indicates the origin of the intended aircraft target altitude in accordance with the following table:

Table 2-10: Target Altitude Source (Bit 55, 56) Encoding

Bit 55, 56	Meaning
0 0	Unknown
0 1	Aircraft Altitude
1 0	FCU / MCP Selected Altitude
1 1	FMS Selected Altitude

b. Alternatively, the transponder may accept information from an appropriate interface or source and use such information to determine the encoding of bits 55, 56 in accordance with Table 2-10.

c. If appropriate information is not available to establish the encoding given in either §2.2.25.5.2.6.2.a or §2.2.25.5.2.6.2.b, then bits 55 and 56 of Register 40_{16} “MB” field **shall** be set to ZERO (0).

2.2.25.5.3 Maximum Update Interval of Register 40_{16}

a. The maximum update interval at which Register 40_{16} **shall** be reloaded with valid data is 1.0 second.

Note: *That is, that Register 40_{16} **shall** be updated at least once every 1.0 second.*

b. The time between availability of data that causes a change in Register 40_{16} and the time that the change is made to Register 40_{16} **shall** be less than the maximum update interval specified as 1.0 seconds.

c. If Altitude Control Panel (MCP /FCU) Selected Altitude in Register 40_{16} “MB” field bits 2 through 13 cannot be updated with valid data within 2.0 seconds (e.g., twice the specified maximum update interval of 1.0 seconds), then Status Bit 1 **shall** be set to ZERO (0) and bits 2 through 13 **shall** be set to ZERO (0).

d. If FMS Selected Altitude in Register 40_{16} “MB” field bits 15 through 26 cannot be updated with valid data within 2.0 seconds (e.g., twice the specified maximum update interval of 1.0 seconds), then Status Bit 14 **shall** be set to ZERO (0) and bits 15 through 26 **shall** be set to ZERO (0).

e. If Barometric Pressure Setting in Register 40_{16} “MB” field bits 28 through 39 cannot be updated with valid data within 2.0 seconds (e.g., twice the specified maximum update interval of 1.0 seconds) then Status Bit 27 **shall** be set to ZERO (0) and bits 28 through 39 **shall** be set to ZERO (0).

f. If the FMS Vertical Mode Bits in Register 40_{16} “MB” field bits 48 through 51 cannot be updated with valid data within 2.0 seconds (e.g., twice the specified maximum update interval of 1.0 seconds), then bits 48 through 51 **shall** be set to ZERO (0).

g. If the Target Altitude Bits in Register 40_{16} “MB” field bits 54 through 56 cannot be updated with valid data within 2.0 seconds (e.g., twice the specified maximum update interval of 1.0 seconds), then bits 54 through 56 **shall** be set to ZERO (0).

2.2.25.6 Register 50_{16} – Track and Turn Report

2.2.25.6.1 Purpose and Introduction

a. Transponders **shall** format Register 50_{16} as defined inAppendix B, Table B-3-80.

b. The transponder **shall** comply with all constraints and requirements for servicing Register 50_{16} that are provided in Appendix B, Table B-3-80.

2.2.25.6.2 Register 50_{16} – Data Requirements

2.2.25.6.2.1 Roll Angle

a. The transponder **shall** process Roll Angle data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 2 through 11 of the Register 50_{16} “MB” field as shown in that table.

b. Bits 2 through 11 **shall** be encoded using two’s complement coding.

c. The data loaded into the “MB” field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 through 11.

e. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 through 11.

f. Bits 2 through 11 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.2 True Track Angle

a. The transponder **shall** process True Track Angle data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 13 through 23 of the Register 50_{16} “MB” field as shown in that table.

b. Bits 13 through 23 **shall** be encoded using two’s complement coding.

c. The data loaded into the “MB” field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 12 **shall** be set to ONE (1) whenever valid data is available in bits 13 through 23.

e. Status Bit 12 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 13 through 23.

f. Bits 13 through 23 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.3 Ground Speed

a. The transponder **shall** process Ground Speed data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 25 through 34 of the Register 50_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 24 **shall** be set to ONE (1) whenever valid data is available in bits 25 through 34.

d. Status Bit 24 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 25 through 34.

e. Bits 25 through 34 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.4 Track Angle Rate

a. The transponder **shall** process Track Angle Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 36 through 45 of the Register 50_{16} "MB" field as shown in that table.

b. Bits 36 through 45 **shall** be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 35 **shall** be set to ONE (1) whenever valid data is available in bits 36 through 45.

e. Status Bit 35 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 36 through 45.

f. Bits 36 through 45 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.2.5 True Airspeed (TAS)

a. The transponder **shall** process True Airspeed (TAS) data from on-board aircraft data sources as provided in Appendix B, Table B-3-80 of the Register 50_{16} definition table and format the data into bits 47 through 56 of the Register 50_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 46 **shall** be set to ONE (1) whenever valid data is available in bits 47 through 56.

d. Status Bit 46 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 47 through 56.

e. Bits 47 through 56 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.6.3 Maximum Update Interval of Register 50_{16}

a. The maximum update interval at which Register 50_{16} **shall** be reloaded with valid data is 1.3 seconds.

Note: *Register 50_{16} is updated at least once every 1.3 seconds.*

b. The time between availability of data that causes a change in Register 50_{16} and the time that the change is made to Register 50_{16} **shall** be less than the maximum update interval specified as 1.3 seconds.

c. If Roll Angle data in Register 50_{16} "MB" field bits 2 through 11 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 1 **shall** be set to ZERO (0) and bits 2 through 11 **shall** be set to ZERO (0).

d. If True Track Angle data in Register 50_{16} "MB" field bits 13 through 23 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds), then Status Bit 12 **shall** be set to ZERO (0) and bits 13 through 23 **shall** be set to ZERO (0).

e. If Ground Speed data in Register 50_{16} "MB" field bits 25 through 34 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 24 **shall** be set to ZERO (0) and bits 25 through 34 **shall** be set to ZERO (0).

f. If Track Angle Rate data in Register 50_{16} "MB" field bits 36 through 45 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 35 **shall** be set to ZERO (0) and bits 36 through 45 **shall** be set to ZERO (0).

g. If True Airspeed (TAS) data in Register 50_{16} "MB" field bits 47 through 56 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 46 **shall** be set to ZERO (0) and bits 47 through 56 **shall** be set to ZERO (0).

2.2.25.7 Register $5F_{16}$ – Quasi-Static Parameter Monitoring

Note: *Enhanced Surveillance does not require that Register $5F_{16}$ be serviced. However, servicing of Register $5F_{16}$ is implicitly required when servicing Register 40_{16} in ICAO Doc. 9871 and Appendix B. Therefore, if Register $5F_{16}$ is serviced, the following subparagraphs need to be complied with.*

2.2.25.7.1 Purpose and Definition

a. Transponders shall format Register $5F_{16}$ as defined in Appendix B, Table B-3-95.

b. The transponder **shall** comply with all constraints and requirements for servicing Register $5F_{16}$ that are provided in Appendix B, Table B-3-95.

2.2.25.7.2 Enhanced Surveillance Servicing Requirements Associated with Register $5F_{16}$

2.2.25.7.2.1 Because of MCP / FCU Selected Altitude

a. Register $5F_{16}$ bits 1 – 2 **shall** be set to "00" whenever MCP / FCU Selected Altitude data is not available to set bits 1 through 13 of Register 40_{16}.

b. Whenever a change is detected in the MCP / FCU Selected Altitude data used to set bits 1 through 13 of Register 40_{16}, the Register $5F_{16}$ bits 1 – 2 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 1-2 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.2 Because of FMS Selected Altitude

a. Register $5F_{16}$ bits 23 – 24 **shall** be set to "00" whenever FMS Selected Altitude data is not available to set bits 14 through 26 of Register 40_{16}.

b. Whenever a change is detected in the FMS Selected Altitude data used to set bits 14 through 26 of Register 40_{16}, the Register $5F_{16}$ bits 23 – 24 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 23 – 24 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.3 Because of Barometric Pressure Setting

a. Register $5F_{16}$ bits 25 – 26 **shall** be set to "00" whenever Barometric Pressure Setting data is not available to set bits 27 through 39 of Register 40_{16}.

b. Whenever a change is detected in the Barometric Pressure Setting data used to set bits 27 through 39 of Register 40_{16}, the Register $5F_{16}$ bits 25 – 26 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 25 – 26 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.4 Because of FMS Vertical Mode

a. Register $5F_{16}$ bits 17 – 18 **shall** be set to "00" whenever FMS Vertical Mode data is not available to set bits 48 through 51 of Register 40_{16}.

b. Whenever a change is detected in the FMS Vertical Mode data used to set bits 48 through 51 of Register 40_{16}, the Register $5F_{16}$ bits 17 – 18 **shall** be incremented by one.

Note 1: *Effectively, the decimal count is as follows: 1, 2, 3, -- 1, 2, 3, etc.*

Note 2: *The binary equivalent setting bits 17 – 18 is as follows: 01, 10, 11, -- 01, 10, 11, etc.*

2.2.25.7.2.5 Other Register $5F_{16}$ Bits

Register $5F_{16}$ bits 3 through 16, 19 through 22, and 27 through 56 **shall** be set to ZERO (0) until such time that the respective parameters identified in Appendix B, Table B-3-95 are being monitored.

2.2.25.7.3 Maximum Update Interval of Register $5F_{16}$

a. The maximum update interval at which Register $5F_{16}$ **shall** be reloaded with valid data is 0.5 seconds.

Note: *Register $5F_{16}$ is updated at least once every 0.5 seconds.*

b. The time between availability of data that causes a change in Register $5F_{16}$ and the time that the change is made to Register $5F_{16}$ **shall** be less than the maximum update interval specified as 0.5 seconds.

c. If a particular data field in Register $5F_{16}$ cannot be updated within 2.0 seconds (i.e., the greater of 2.0 seconds or twice the specified maximum update interval of 0.5 seconds), then the data field **shall** be ZEROed (i.e, binary "00").

2.2.25.8 Register 60_{16} – Heading and Speed Report

2.2.25.8.1 Purpose and Definition

a. Transponders **shall** format Register 60_{16} as defined in Appendix B, Table B-3-96.

b. The transponder **shall** comply with all constraints and requirements for servicing Register 60_{16} that are provided in Appendix B, Table B-3-96.

2.2.25.8.2 Register 60_{16} – Data Requirements

2.2.25.8.2.1 Magnetic Heading

a. The transponder **shall** process Magnetic Heading data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 2 through 12 of the Register 60_{16} "MB" field as shown in that table.

b. Bits 2 through 12 **shall** be encoded using two's complement coding.

c. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 1 **shall** be set to ONE (1) whenever valid data is available in bits 2 through 12.

e. Status Bit 1 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 2 through 12.

f. Bits 2 through 12 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.2 Indicated Airspeed

a. The transponder **shall** process Indicated Airspeed data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 14 through 23 of the Register 60_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 13 **shall** be set to ONE (1) whenever valid data is available in bits 14 through 23.

d. Status Bit 13 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 14 through 23.

e. Bits 14 through 23 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.3 Mach

a. The transponder **shall** process Mach data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 25 through 34 of the Register 60_{16} "MB" field as shown in that table.

b. The data loaded into the "MB" field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

c. Status Bit 24 **shall** be set to ONE (1) whenever valid data is available in bits 25 through 34.

d. Status Bit 24 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 25 through 34.

e. Bits 25 through 34 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.4 Barometric Altitude Rate

a. The transponder **shall** process Barometric Altitude Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register 60_{16} definition table and format the data into bits 36 through 45 of the Register 60_{16} “MB” field as shown in that table.

b. Bits 36 through 45 **shall** be encoded using two’s complement coding.

c. The data loaded into the “MB” field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 35 **shall** be set to ONE (1) whenever valid data is available in bits 36 through 45.

e. Status Bit 35 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 36 through 45.

f. Bits 36 through 45 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.2.5 Inertial Vertical Rate

a. The transponder **shall** process Inertial Vertical Rate data from on-board aircraft data sources as provided in Appendix B, Table B-3-96 of the Register $60_{1}6$ definition table and format the data into bits 47 through 56 of the Register 60_{16} “MB” field as shown in that table.

b. Bits 47 through 56 **shall** be encoded using two’s complement coding.

c. The data loaded into the “MB” field **shall** be rounded so as to preserve accuracy of the source data within ±½ LSB.

d. Status Bit 46 **shall** be set to ONE (1) whenever valid data is available in bits 47 through 56.

e. Status Bit 46 **shall** be set to ZERO (0) whenever there is no valid data with which to fill bits 47 through 56.

f. Bits 47 through 56 **shall** be set to ZERO (0) whenever there is no valid data with which to fill the bits.

2.2.25.8.3 Maximum Update Interval of Register 60_{16}

a. The maximum update interval at which Register 60_{16} **shall** be reloaded with valid data is 1.3 seconds.

Note: *Register 60_{16} is updated at least once every 1.3 seconds.*

b. The time between availability of data that causes a change in Register 60_{16} and the time that the change is made to Register 60_{16} **shall** be less than the maximum update interval specified as 1.3 seconds.

c. If Magnetic Heading data in Register 60_{16} “MB” field bits 2 through 12 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 1 **shall** be set to ZERO (0) and bits 2 through 12 **shall** be set to ZERO (0).

d. If Indicated Airspeed data in Register 60_{16} “MB” field bits 14 through 23 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 13 **shall** be set to ZERO (0) and bits 14 through 23 **shall** be set to ZERO (0).

e. If Mach data in Register 60_{16} “MB” field bits 25 through 34 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 24 **shall** be set to ZERO (0) and bits 25 through 34 **shall** be set to ZERO (0).

f. If Barometric Altitude Rate data in Register 60_{16} “MB” field bits 36 through 45 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 35 **shall** be set to ZERO (0) and bits 36 through 45 **shall** be set to ZERO (0).

g. If Inertial Vertical Rate data in Register 60_{16} “MB” field bits 47 through 56 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 46 **shall** be set to ZERO (0) and bits 47 through 56 **shall** be set to ZERO (0).

2.2.26 Generic Register XX_{16} Requirements

The following subsections provide generic requirements that can be used as a basis to verify transponders that implement Registers that have not been defined in detail in this document. When an additional Register is implemented that is not covered in §2.2.24 or §2.2.25, then the requirements in the following subsections will revert to the use of the requirement word “shall” instead of “will.”

Note: *In the following subsections, “**ddd**” means the decimal equivalent to $\mathbf{XX_{16}}$. For instance, for 40_{16}, “**ddd**” = 64_{10} = 64.*

2.2.26.1 Purpose and Definition

a) Transponders will format Register $\mathbf{XX_{16}}$ as defined in Appendix B, Table B-3-**ddd**.

b) The transponder will comply with all constraints and requirements for servicing Register $\mathbf{XX_{16}}$ that are provided with Table B-3-**ddd** in Appendix B.

2.2.26.2 Data Requirement

2.2.26.2.1 Data Field “y”

a. The transponder will process data from on-board aircraft data sources as provided in Appendix B, Table B-3-**ddd** of Register $\mathbf{XX_{16}}$ definition table and format the data into field “**y**” of the Register $\mathbf{XX_{16}}$ “MB” field as shown in that table.

b. Field “**y**” will be encoded using two’s complement coding if it is a signed arithmetic field unless otherwise specified.

c. The data loaded into the "MB" field will be rounded so as to preserve accuracy of the source data within ±1/2 LSB.

d. Status Bit of field "**y**" will be set to ONE (1) whenever valid and up-to-date data (data not older than twice the maximum update interval specified in Table B-2-1 in Appendix B) is available in field "**y**".

e. Status Bit of field "**y**" will be set to ZERO (0) whenever there is no valid and up-to-date data with which to fill field "**y**".

f. The data bits of field "y" will be set to ZERO if the Status Bit is set to ZERO.

g. Any Reserved Bits will be set to ZERO.

Note 1: *On an ARINC platform, when data is available in BCD and in binary, transponders will preferably use binary data rather than BCD data.*

Note 2: *When multiple sources of data are available for a given field "**y**", transponders will use the data source that is being used to manage the aircraft profile or the source selected by the flight crew. This general convention applies unless the highest integrity data is desired as in Automatic Dependent Surveillance – Broadcast (ADS-B). In such cases, the highest integrity source will be used for data.*

2.2.26.3 Update Rate

a. The maximum update interval at which a data field in a Register will be reloaded with valid data is defined for each register in Table B-2-1 in Appendix B.

b. The transponder will load valid data into the related transponder Register as soon as it becomes available at the Mode S Specific Services entity.

c. The time between availability of data that causes a change in a data-field of a Register and the time that the change is made to the Register will be less than the maximum update interval specified in Table B-2-1 in Appendix B.

d. If a data-field field cannot be updated with valid data within twice the specified maximum update interval defined for the Register or 2 seconds (whichever is the greater), then Status Bit (if specified) of the field will be set to ZERO (0) (INVALID) and that data field will be ZEROed.

2.2.26.4 Service Reporting

a. The transponder will report Mode-S Specific Services Capability Reports (installation capability) in transponder Registers 18_{16} to $1C_{16}$.

b. The transponder will update the common usage GICB Capability Report (transponder Register 17_{16}) while periodically checking the availability of the related data.

c. The transponder will promptly update the Data Link Capability Report (transponder Register 10_{16} bit 25 and bit 36 and broadcast Register 10_{16} in case of change in Register 10_{16}.

2.3 Equipment Performance – Environmental Conditions

The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operations.

Some of the environmental tests contained in this subsection need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase "When Required." If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these "when required" tests **shall** be performed.

The test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA Document DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, December 8, 2010.

Some of the performance requirements in Subsections §2.1 and §2.2 are not tested by the test procedures herein. Moreover, not all tests are required to be done at each of the environmental conditions in RTCA/DO-160G. Judgment and experience have indicated that these particular performance parameters are not susceptible to certain environmental conditions and that the level of performance specified in Subsections §2.1 and §2.2 will not be measurably degraded by exposure to these environmental conditions.

The specified performance tests cover all classes of Mode S transponders. Only those tests that are applicable to the class of transponder being qualified need be done. Additional tests may have to be performed in order to determine performance of particular design requirements that are not specified in this document. It is the responsibility of the manufacturer to determine appropriate tests for these functions.

Specific transponder performance tests have been included in this section for use in conjunction with the environmental procedures of RTCA/DO-160G. These tests have been judiciously chosen as a subset of the transponder performance tests of Subsection §2.4. Normally, a MOPS document does not provide specific equipment performance tests to be used in conjunction with the environmental procedures of RTCA/DO-160G. However, there is a sufficiently large number of transponder performance tests in Subsection §2.4 that it would be impractical to repeat all of those tests in conjunction with all of the appropriate environmental procedures.

2.3.1 Environmental Test Conditions

Table 2-11 lists all of the environmental conditions and test procedures (hereafter referred to as environmental procedures) that are documented in RTCA/DO-160G. Table 2-12 lists the 16 sets of transponder performance tests that are specified in detail in this section and which are intended to be run subject to the various environmental procedures of RTCA/DO-160G. In order to simplify the process of relating the environmental procedures to the transponder performance tests, Table 2-11 divides the environmental procedures into groups. All of the procedures in a given group are carried out in conjunction with the same set of transponder performance tests. Using this approach, the environmental procedures fall into six groups. The environmental procedures that apply to all of the sets of transponder performance tests fall into Group 1. Group 2 procedures apply to 12 of the sets of transponder performance tests. Groups 3, 4, and 5 apply to 6, 4 and 4 of the sets of transponder performance tests, respectively. (Group 6, which applies to none of the transponder performance tests, includes only environmental procedures that are intended to determine the effect of the transponder on rack mounting hardware, compass needles, explosive gasses, and other RF hardware.)

Table 2-12 indicates which of the groups of environmental procedures is related to each set of transponder performance tests. Each transponder performance test **shall** be validated under all of the environmental procedures in the groups required for that test as indicated in Table 2-12.

Table 2-11: Environmental Test Groups

	ENVIRONMENTAL CONDITION	DO-160G Paragraph	GROUPS	REMARKS
4a	Temperature	§4.5	1	
4b	Altitude	§4.6.1	4	
4c	Decompression & Overpressure	§4.6.2-§4.6.3	4	When required
5	Temperature Variation	§5.0	3	
6	Humidity	§6.0	2	
7a	Operational Shock	§7.2	2	When required
7b	Crash Safety	§7.3	6	See Note below
8	Vibration	§8.0	3 & 1	3 during, 1 after
9	Explosion	§9.0	6	See Note below
10	Waterproofness	§10.0	2	When required
11	Fluids Susceptibility	§11.0	2	When required
12	Sand and Dust	§12.0	2	When required
13	Fungus Resistance	§13.0	2	When required
14	Salt Spray	§14.0	2	When required
15	Magnetic Effect	§15.0	6	See Note below
16	Power Input	§16.0	5	
	Momentary Interruptions All Others		3 & 2	3 during, 2 after
17	Voltage Spike	§17.0	2	
18	Audio Freq. Conducted Susceptibility	§18.0	1	
19	Induced Signal Susceptibility	§19.0	1	
20	RF Susceptibility	§20.0	1	
21	Emission of RF Energy	§21.1	6	See Note below
22	Lightning Induced Transient Susceptibility	§22.0	3	
23	Lightning Direct Effects	§23	3	When required
24	Icing	§24	3	When required
25	Electrostatic Discharge	§25	2	2 after
26	Fire / Flammability	§26	2	When required, 2 after

Notes for Table 2-11:

1. *Tests in Group 6 determine the effects of the transponder on other equipment (mounts, compass needles, explosive gasses, and other RF equipment) and therefore do not involve the transponder performance requirements of this document.*
2. *"When Required" in the above table means when necessary to support installation issues and is not specifically required by these MOPS.*

Table 2-12: Performance Test Requirements During Environmental Tests

Test Procedure Paragraph	DESCRIPTION	REQUIRED ENVIRONMENT TEST GROUPS (See Table 2-11)					
		1	2	3	4	5	6
§2.3.2.1	Receiver Characteristics	x	x	x			
§2.3.2.2.1	Reply Transmission Frequency	x	x	x	x		
§2.3.2.2.2	RF Peak Power Output	x	x		x		
§2.3.2.2.3	Reply Rate Capability	x					
§2.3.2.3	Reply Pulse Characteristic	x					
§2.3.2.4	Side Lobe Suppression	x	x				
§2.3.2.5	Pulse Decoder Characteristic	x	x				
§2.3.2.6	Transponder Recovery & Desens.	x					
§2.3.2.7	Standard Interference Pulse	x					
§2.3.2.8	Undesired Replies	x		x		x	
§2.3.2.9	Self-Test and Monitors	x	x	x	x	x	
§2.3.2.10	Diversity Operation	x	x				
§2.3.2.11	Data Handling & Interfaces	x	x				
§2.3.2.12	Restoration of Power	x	x			x	
§2.3.2.13	Acquisition Squitter	x	x	x	x	x	
§2.3.2.14	Extended Squitter	x					

2.3.2 Detailed Environmental Test Procedures

The test procedures set forth below are considered satisfactory for use in determining equipment performance under environmental conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures. These transponder performance tests do not include specific pass fail criteria. It is intended that those criteria be obtained from the transponder performance requirements presented in the referenced paragraphs in §2.2.

2.3.2.1 Receiver Characteristics (§2.2.2)

Step 1 Sensitivity Variation with Frequency (§2.2.2.2)

Using a standard Mode A interrogation, interrogate the transponder at RF signal frequencies of 1029.8, 1030.0 and 1030.2 MHz. Determine the required maximum RF signal level at each frequency required to produce 90% reply efficiency.

Step 2 Sensitivity (§2.2.2.4.a.)

Interrogate the transponder with a standard Mode C ATCRBS/Mode S All-Call interrogation. Determine the minimum RF signal level required to produce 90% transponder reply efficiency.

Step 3 ATCRBS and ATCRBS/Mode S All-Call Dynamic Range (§2.2.2.4.f)

Interrogate the transponder with a standard Mode A interrogation at RF levels from MTL +3 dB to -21 dBm in approximately 5 equal steps. Determine reply ratio. Repeat for a standard Mode C ATCRBS/Mode S All-Call.

Step 4 ATCRBS/Mode S All-Call Low-Level Reply Ratio (§2.2.2.4.d.)

Interrogate the transponder with a standard Mode C ATCRBS/Mode S All-Call at an RF level of -81 dBm. Determine reply ratio.

Step 5 Mode S Sensitivity (§2.2.2.4.b.)

Interrogate the transponder with a Mode S Only All-Call interrogation at a standard rate with PR=0. Determine the minimum RF level to produce 90% proper reply efficiency.

Step 6 Mode S Dynamic Range (§2.2.2.4.c.)

Using the signal specified in Step 5, determine the reply efficiency for RF levels of MTL +3 dB, -50 dBm and -21 dBm.

Step 7 Mode S Low-Level Reply Ratio (§2.2.2.4.d.)

Using the signal specified in Step 5, determine reply efficiency for an RF level of -81 dBm.

2.3.2.2 Transmitter Characteristics (§2.2.3)

2.3.2.2.1 Reply Transmission Frequency (§2.2.3.1)

Interrogate the transponder with a standard Mode A interrogation. Use a 14 (7777) pulse reply group. Repeat with a standard Mode A ATCRBS/Mode S All-Call. Determine the reply frequency for both reply types.

2.3.2.2.2 RF Peak Power Output (§2.2.3.2)

Step 1 ATCRBS Power Output (§2.2.3.2)

Connect the equipment as shown in Figure 2-31. Set the transponder for a 14-pulse (7777) reply. Interrogate the transponder with a standard Mode A interrogation at 1200 interrogations per second or the maximum for which the transponder is designed and measure the single pulse having the least RF power output. Determine that the power output meets the requirements of §2.2.3.2.

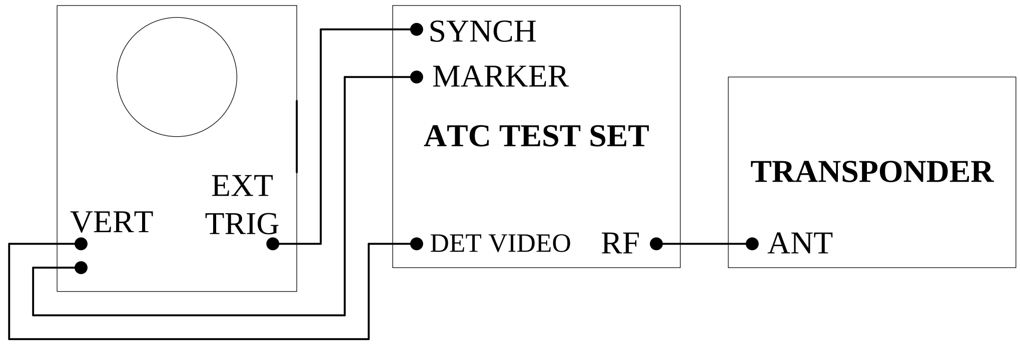


Figure 2-31: Test Equipment Connection

Step 2 Short Mode S Power Output (§2.2.3.2)

Repeat Step 1 with a standard Mode A ATCRBS/Mode S All-Call interrogation at the standard rate.

Step 3 Long Mode S Power Output

For transponders with long reply capability (Level 2 or above), repeat Step 1 with sixteen Mode S interrogations per second using any format and coding for which a long reply is required.

If the transponder is also Extended Squitter capable, then configure the transponder so that the transponder is transmitting the Extended Squitters (or an equivalent number of long replies) in addition to the sixteen replies.

Step 4 Extended Long Mode S Power Output (§2.2.3.5)

For transponders with extended reply capability (Level 4 or above), repeat Step 3, stimulating the maximum rate of long replies for which the transponder is designed.

Note: *The reply rate capability has to take into account 25% surplus transmitting capability. (e.g., if the transponder has declared the capacity to deliver the maximum of **N** ELM segments per second, it has to deliver **N** + 25% of **N** in a 25-millisecond interval of each second as defined in §2.2.3.5).*

2.3.2.2.3 Reply Rate Capability

Step 1 ATCRBS Reply Rate Capability (§2.2.3.4.1.a and §2.2.3.4.2)

Set the transponder for a 15-pulse ATCRBS reply. Interrogate the transponder at a constant rate of 500 ATCRBS interrogations per second plus 50 Mode S interrogations (with short replies) per second. Measure the output power and frequency. If the transponder is equipped for long Mode S reply formats, repeat the test with 16 (24 if also equipped with the enhanced data link protocols) of the 50 Mode S interrogations requiring long replies.

Step 2 Continuous Reply Rate Capability (§2.2.3.4.1.a and §2.2.3.4.2)

Set the transponder for a 14 pulse plus SPI-pulse ATCRBS reply. Interrogate the transponder at a constant rate of 500 ATCRBS interrogations per second plus 50 Mode S interrogations (with short replies) per second. If the transponder is equipped for long Mode S reply formats, have 16 (24 if also equipped with the enhanced data link protocols) of the 50 Mode S interrogations requiring long replies. Determine reply ratio for each type of interrogation.

Step 3 100 Milliseconds Peak Reply Rate Capability (§2.2.3.4.1 b & c and §2.2.3.4.2)

Set the transponder for a 14 pulse plus SPI-pulse ATCRBS reply. Interrogate the transponder with periodic bursts of ATCRBS and Mode S interrogations as follows: 120 ATCRBS interrogations (100 for Class 2 equipment) plus 18 Mode S interrogations (with short replies), each type of interrogation approximately uniformly spaced within a single 0.1-second interval, followed by a 0.9-second interval with no interrogations. If the transponder is equipped for long Mode S reply formats, have 6 (9 if also equipped with the enhanced data link protocols) of the 18 Mode S interrogations requiring long replies. Determine reply ratio for each type of interrogation.

Step 4 25 Millisecond Peak Reply Rate Capability (§2.2.3.4.2)

Set the transponder for a 14 pulse plus SPI-pulse ATCRBS reply. Interrogate the transponder with periodic bursts of ATCRBS and Mode S interrogations as follows: 30 ATCRBS interrogations (25 for Class 2 equipment) plus 8 Mode S interrogations (requiring short replies), each type of interrogation burst approximately uniformly spaced within a single 25-millisecond interval, followed by a 975-millisecond interval without interrogations. If the transponder is equipped for long Mode S reply formats, have 4 (6 if also equipped with the enhanced data link protocols) of the 8 Mode S interrogations requiring long replies. Determine reply ratio for each type of interrogation.

Step 5 1.6 Milliseconds Peak Reply Rate Capability (§2.2.3.4.1 and §2.2.3.4.2)

Repeat Step 3 with the following modification: Use two ATCRBS interrogations plus four Mode S interrogations (with short replies), each type of interrogation approximately uniformly spaced within a single 1.6-millisecond interval, followed by a 998.4-millisecond interval with no interrogation. If the transponder is so equipped, two of the Mode S interrogations require long replies instead of all short replies. Determine reply ratio for each type of interrogation.

2.3.2.3 Reply Pulse Characteristics (§2.2.4)

2.3.2.3.1 ATCRBS Reply Pulse Characteristics (§2.2.4.1)

Step 1 ATCRBS Reply Pulse Spacing and Width (§2.2.4.1)

Interrogate with a standard Mode A interrogation. Use a 15-pulse reply group (7777 with SPI) and measure the time between the first and last framing pulses. This time **shall** be 20.30 ±0.10 microseconds. Measure the width of the first and last pulses. This width **shall** be 0.45 ±0.10 microseconds. Observe that all code pulses are of equal width and stable in position with respect to the first pulse.

Step 2 Reply Delay and Jitter (§2.2.4.1.6.a and §2.2.4.1.6.b)

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard Mode A interrogation. Measure the average delay between the leading edge of P_3 and the leading edge of the first reply pulse at the 50% amplitude points and the extreme positions of the leading edge of the first reply pulse at signal levels of MTL +3 dB, -50 dBm and -21 dBm.

2.3.2.3.2 Mode S Replies (§2.2.4.2)

Note: *Under environmental conditions, the following test procedure is required only under High Operating Temperature conditions.*

Step 1 Mode S Preamble (§2.2.4.2.1)

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard Mode A ATCRBS/Mode S All-Call. Display the Mode S reply on the oscilloscope. Measure the pulse duration of the first four reply pulses. Measure pulse spacing between the leading edge of the first and each of the second, third and fourth pulses.

Step 2 Mode S Reply Data Pulses (§2.2.4.2.2)

Note: *For Steps 2 through 6, examine pulses at the beginning, middle and end of the replies.*

Connect equipment as in Figure 2-31. Measure the pulse duration for both short and long reply pulses throughout the Mode S reply.

Measure the pulse spacing of the fifth reply pulse with reference to the first reply pulse.

Step 3 Mode S Reply Amplitude Variation (§2.2.4.2.3.a)

Connect the equipment as in Figure 2-31. Measure the maximum power differential between pulses in the Mode S reply.

Step 4 Mode S Reply Pulse Shape (§2.2.4.2.3.b)

Measure the rise time of the reply pulses.

CAUTION: *If the detector is not known to be linear, checks should be made to determine what amplitude points on the detected pulse correspond to the 10 percent and 90 percent amplitude points of the RF pulses. In addition, checks should be made to determine the rise and decay time of the detector.*

Step 5 Mode S Reply Pulse Spacing Tolerance (§2.2.4.2.4)

Connect equipment as in Figure 2-31. Determine that the leading edge of any reply pulse is within 50 nanoseconds of its assigned position.

Step 6 Long Replies (§2.2.4.2.1 through §2.2.4.2.4)

Repeat Steps 1 through 5 using interrogations which require long replies.

2.3.2.4 Side Lobe Suppression (§2.2.5)

Step 1 SLS Decoding [§2.2.5.1.a (1) and (3)]

Connect the equipment as shown in Figure 2-32. Interrogate the transponder with a standard Mode A interrogation plus P_2 RF signal level to be at MTL +3 dB; P_2 level = P_1 level. Verify that the reply ratio is no more than one percent.

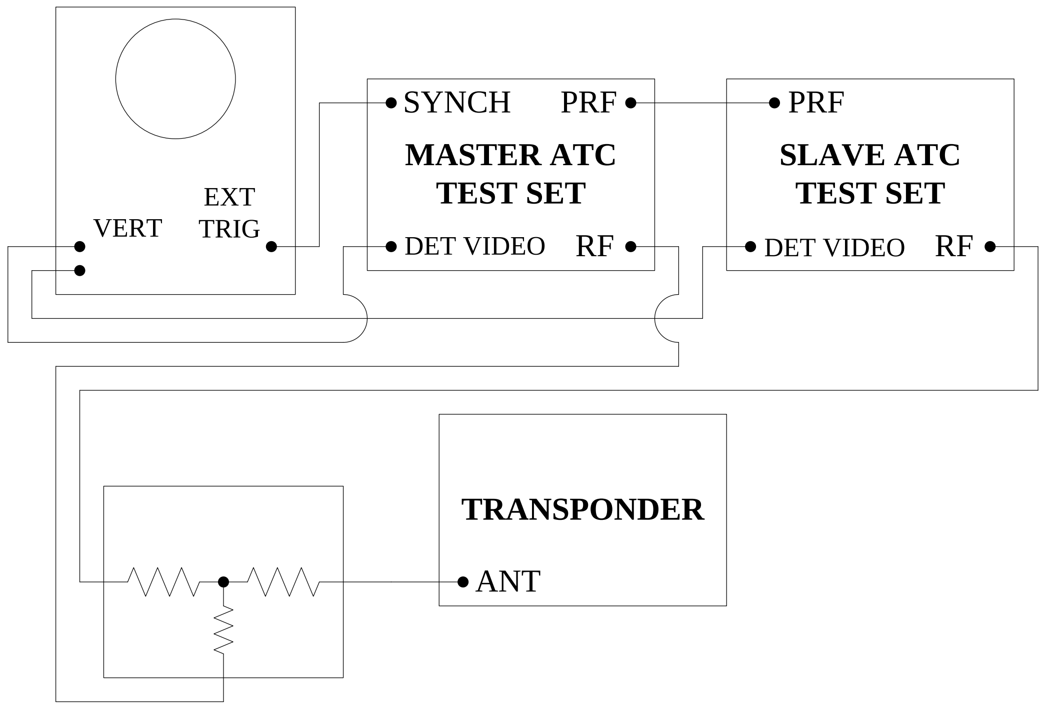


Figure 2-32: Test Equipment Connection

Step 2 SLS Dynamic Range [§2.2.5.1.a (2) and §2.2.5.1.c]

Repeat Step 1 at RF signal levels: -60 dBm, -40 dBm and -21 dBm.

Step 3 SLS Pulse Ratio (§2.2.5.1.b)

Repeat Step 1 at RF signal levels MTL +3 dB, -50 dBm and -21 dBm. Set P_2 level 9 dB below P_1 level. Verify that the reply efficiency is at least 90%.

Step 4 Suppression Duration [§2.2.5.1.d (1)]

Interrogate the transponder with a P_1 - P_2 ATCRBS suppression pulse pair (2 microsecond spacing), followed after 50 microseconds with a P_1 - P_3 (Mode A, 8 microseconds) pulse pair. Reduce the spacing of the P_1 - P_3 pair until the transponder reply rate is below 1%. The time interval between the leading edges of P_2 and P_1 (of the P_1 - P_3 pair) is the suppression duration. Repeat the procedure using P_1 – P_3 (Mode C, 21 microseconds) pulse pair interrogations.

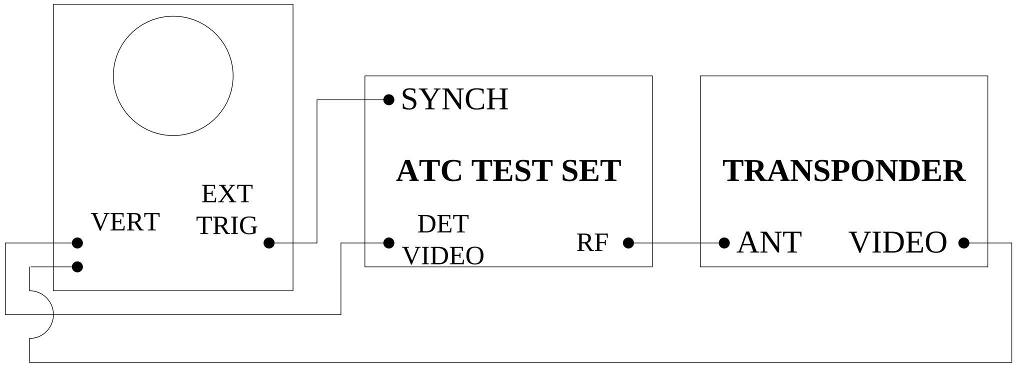


Figure 2-33: Test Equipment Connection

2.3.2.5 Pulse Decoder Characteristics (§2.2.6)

Step 1 Pulse Level Tolerances, ATCRBS/Mode S All-Call (§2.2.6.1.1)

Connect the equipment as shown in Figure 2-31. Interrogate at the standard rate and at an input level 10 dB above MTL. Use an ATCRBS Mode A interrogation followed by a 1.6-microsecond P_4 pulse in its nominal position. Vary the level of the P_4 pulse between -10 and 0 dB in 1 dB steps with respect to P_3. Verify the changeover from ATCRBS to Mode S replies at the relative P_4 levels specified in §2.2.6.1.1.a and §2.2.6.1.1.b when more than 90% of the replies are Mode S or ATCRBS.

Step 2 Pulse Level Tolerances, ATCRBS-Only All-Call (§2.2.6.1.2)

Use setup and signal levels as in Step 1 above but employ a 0.8 microsecond P_4. Vary the level of the P_4 pulse between -10 and 0 dB in 1 dB steps with respect to P_3. Verify the changeover from ATCRBS replies to no replies at the relative P_4 levels specified in §2.2.6.1.2.a and §2.2.6.1.2.b.

Step 3 Pulse Position Tolerances, $P_{1/3}$, ATCRBS-Type Interrogations (§2.2.6.2 a and b)

Use setup and signal levels as in Step 1 above. Interrogate with:

a. ATCRBS Mode A

b. ATCRBS Mode C/Mode S All-Call

For each interrogation type vary the P_1 - P_3 spacing within the required acceptance range (§2.2.6.2.a) and verify that the reply ratio is at least 90%.

Step 4 Pulse Position Tolerances, P_4, ATCRBS/Mode S All-Calls (§2.2.6.2 a and c)

Use setup and signal levels as in Step 1 and interrogate with an ATCRBS Mode A/Mode S All-Call. Vary the P_3 - P_4 spacing within the required acceptance range. Determine conformance to requirements as in Step 3.

Step 5 Pulse Duration Tolerances, Mode A/C Interrogations (§2.2.6.3)

Using signal levels as in Step 1 above, interrogate with

(1) Mode A,

(2) Mode C. For each interrogation type,

- vary the P_1 duration within the required acceptance range and record the minimum reply ratio;

- vary the P_1 duration to fall out of the permitted acceptance range and record the maximum reply ratio.

Repeat test varying the P_3 duration in the same manner.

Note: *Under environmental conditions, this procedure is only required when performing Temperature testing. Also, when doing such testing, it is acceptable to vary duration of P_1 and P_3 at the same time if that is the capability of the Mode S Test Equipment being used.*

Step 6 Pulse Duration Tolerance, Mode A/C/S All-Call Interrogations (§2.2.6.3)

Using signal levels as in Step 1 above, interrogate with:

(1) Mode A/Mode S All-Call,

(2) Mode C/Mode S All-Call. For each interrogation type,

- vary the P_1 duration within the required acceptance range and record the minimum reply ratio;

- vary the P_1 duration to fall out of the permitted acceptance range and record the maximum reply ratio.

Repeat the test, varying the P_3 duration in the same manner. Repeat the test, varying the P_4 duration in the same manner.

Note: *Under environmental conditions, this procedure is only required when performing Temperature testing. Also, when doing such testing, it is acceptable to vary duration of P_1 and P_3 at the same time if that is the capability of the Mode S Test Equipment being used.*

Step 7 Short Pulse Rejection, ATCRBS-Type Interrogations (§2.2.6.3.c)

Use setup as in Step 1 and set signal input level to MTL for each of the following interrogation types:

a. ATCRBS Mode A

b. ATCRBS Mode C/Mode S All-Call

For each interrogation type set P_1 duration to 0.25 microseconds and verify that less than 10% replies are generated. Repeat test for a P_3 duration of 0.25 microseconds. Repeat tests at -60 dBm and -45 dBm input level.

Step 8 Sync Phase Reversal Position Tolerance (from P_2) (§2.2.6.4)

Generate a standard Mode S-Only All-Call interrogation at MTL +3 dB. Vary the spacing between the P_6 sync phase reversal and either P_2 or P_6 as applicable by 200 nanoseconds from the nominal spacing. Measure the range over which Mode S replies are received. Repeat for P_1 levels of -50 dBm and -21 dBm.

2.3.2.6 Transponder Recovery and Desensitization (§2.2.7)

Step 1 ATCRBS Single Pulse Desensitization and Recovery (§2.2.7.1.1 and §2.2.7.2)

Connect the equipment as shown in Figure 2-32. Set the master test set to generate a single pulse not less than 0.7 microseconds wide at the standard ATCRBS interrogation rate and a power level equal to 50 dB above MTL. Set the slave test set to generate an ATCRBS Mode A interrogation delayed 3 microseconds from the trailing edge of the single pulse. Determine the amplitude of the slave test set signal required to produce 90% reply efficiency. Repeat for master to slave test set delay of 15 microseconds.

Step 2 Recovery from a Mode S Interrogation Requiring No Reply (§2.2.7.2.1)

With the equipment connected as shown in Figure 2-32, set the master test set to generate a short Mode S surveillance interrogation with broadcast address. Set the slave test set to generate an ATCRBS Mode A interrogation at a power level equal to 3 dB above MTL. Measure the delay time between the master and the slave test sets necessary to elicit a reply efficiency of 90%.

Step 3 Recovery from a Mode S Comm-C Interrogation (§2.2.7.2.1)

With equipment connected as shown in Figure 2-32, set the master test set to generate the initial segment of a properly addressed Comm-C interrogation at a signal level of -21 dBm. Set the slave test set to generate an ATCRBS Mode A inter-rogation delayed 45 microseconds from the sync phase reversal of the master interrogation. Determine the amplitude of the slave test signal required to produce 90% reply efficiency.

Step 4 Recovery from a Suppression Pair (§2.2.7.2.2)

With equipment connected as shown in Figure 2-32, set the master test set to generate a P_1 - P_2 pulse pair at the ATCRBS standard interrogation rate and a power level equal to -35 dBm. Set the slave test set to generate a Mode S-Only All-Call interrogation delayed 10 microseconds from the trailing edge of the P_2 pulse of the master test set interrogation. Determine the amplitude of the slave test set signal required to produce 90% reply efficiency.

2.3.2.7 Standard Interference Pulse (§2.2.8.2) and Mode S SLS (§2.2.5.2)

Connect the equipment as shown in Figure 2-32. Interrogate the transponder with an interfering pulse (duration: 0.8 microseconds, level 6 dB below P_6) inserted at a position 1.8 microseconds after the leading edge of P_6 of a standard Mode S-Only All-Call. The Mode S-Only All-Call **shall** be at a power level of -50 dBm. Observe the reply ratio while slowly moving the interfering pulse from its initial position to the end of P_6. Repeat the test for signal levels of -21, and -68 dBm.

Repeat the test with an interference pulse level 3 dB below the P_6 level.

Insert the interfering pulse (now acting as P_5) 0.85 microseconds after the leading edge of P_6 and use a level 3 dB above the level of P_6. Use signal levels of MTL +3 dB and -21 dBm. Reply ratio in all cases should be 10% or less (§2.2.5.2.a).

Reduce the level of P_5 to a value 12 dB below the level of P_6 and repeat the test at signal levels of MTL +3 dB and -21 dBm. Reply ratio should be 99% or more (§2.2.5.2.b).

2.3.2.8 Undesired Replies (§2.2.9)

With no interrogations count the number of replies for a minimum of one minute.

2.3.2.9 Self-Test and Monitors (§2.2.10)

Step 1 Self-Test Interrogation/Reply Rate (§2.2.10.1 a and c)

Activate the self-test function (if provided) of the transponder under test and determine the reply rate to the self-test interrogation.

Step 2 Squitter Monitor (§2.2.10.2)

A specific test procedure for this function is not described. This test requires that the manufacturer artificially disable the squitter generation function. The detailed procedure for proving this capability must be left to the discretion of the manufacturer.

2.3.2.10 Diversity Operation (§2.2.12)

Two means of generating identical ATCRBS and Mode S interrogations which can be delayed from each other from 125 to 375 nanoseconds must be provided. These two generators must also have independent control of power level.

Means of determining the antenna terminal that generates the reply.

Means of determining the reply power level on both antennas simultaneously.

Means of determining reply delay for each channel and between channels.

Measurement Procedure:

Note: *Because the specifications for diversity operations are symmetrical in all respects, channels are arbitrarily designated A and B.*

Step 1 Single Channel Test (§2.2.12.3 and §2.2.12.4)

When measuring channel A and B parameters take care that any cables used for measurements are of equal length and equal loss. Interrogate channel A only, while monitoring channel A and B. At signal level MTL +6 dB use the following types of interrogations and record the listed observations:

ATCRBS Mode A

ATCRBS Mode C/Mode S All-Call

Mode S formats UF=4, and if so equipped 20

For signal levels of -50 dBm and -21 dBm use an ATCRBS Mode A and a Mode S format of UF=4 types of interrogations and record the listed observations.

Observe: Correct reply channel.

Reply delay for each interrogation signal type and for the signal levels as specified.

Correct power ratio per §2.2.12.3.

Repeat the above test reversing channels.

Compare records of reply delays for conformance with §2.2.12.4.

Step 2 Selection Test (§2.2.12.1.b)

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.040 microseconds apart where channel A is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL and a power level on channel B of MTL +6 dB.

Observe that the correct reply channel is channel B.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +6 dB and a power level on channel B of MTL.

Observe that the correct reply channel is channel A.

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.040 microseconds apart where channel B is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL and a power level on channel B of MTL +6 dB.

Observe that the correct reply channel is channel B.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +6 dB and a power level on channel B of MTL.

Observe that the correct reply channel is channel A.

Step 3 Delay-Selection Test (§2.2.12.2)

Synchronize the interrogations to channels A and B so that they are 0.375 +0.040/-0.00 microseconds apart where channel A is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +6 and a power level on channel B of -50 dBm.

Observe that the correct reply channel is channel A.

Synchronize the interrogations to channels A and B so that they are 0.375 +0.040/-0.00 microseconds apart where channel B is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of -50 dBm and a power level on channel B of MTL +6.

Observe that the correct reply channel is channel B.

2.3.2.11 Data Handling and Interfaces (§2.2.13)

2.3.2.11.1 Fixed Direct Data (§2.2.13.1.1)

With the transponder RF port connected to the RF port of the Mode S transponder test set, perform the following test sequences.

Step 1 Mode S All-Call Addresses [§2.2.13.1.1.a (1)]

Interrogate the transponder with a Mode-S Only All-Call interrogation with PR, IC and CL fields set to ZERO. Verify that the AA field of the transponder reply reflects the address which has been set into the transponder. Use two different addresses consisting of AAAAAAH and 555555H.

Step 2 Mode S Discrete Address [§2.2.13.1.1.a (2)]

Interrogate the transponder with a standard Mode S surveillance-altitude interrogation (UF=4) with the PC, RR, DI and SD fields set to 0 and an address consisting of ONE followed by 23 ZEROs. Verify that the transponder replies with appropriate bits set in the AP field when a like address is set into the transponder, and will not respond when each of the other combinations of 23 ZEROs and a single ONE are entered as addresses.

Step 3 Maximum Airspeed [§2.2.13.1.1.b (2)]

Interrogate the transponder with a short special surveillance interrogation (UF=0) with the AQ field set to 1. Verify that the RI field of the transponder reply corresponds to the airspeed code set into the transponder as each of the seven possible airspeed codes is used.

Step 4 Aircraft Identification Data (§2.2.13.1.1.c)

Perform the test procedure provided in §2.6.6.3.a and §2.6.6.3.b.

2.3.2.11.2 Variable Direct Data (§2.2.13.1.2)

Step 1 Pressure Altitude (ATCRBS) [§2.2.13.1.2.a (1)]

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard ATCRBS Mode C interrogation. With the ALT switch on, set altitude code inputs to the transponder, which should result in setting each of the altitude bits in the reply one at a time. Verify proper positioning of these bits in the reply. Verify that only the framing pulses are present in the reply when the ALT switch is set to "off."

Step 2 4096 Identification Code (ATCRBS) (§2.2.13.1.2.b)

With equipment connected as in Step 1, interrogate the transponder with a standard ATCRBS Mode A interrogation. Set identification codes which should result in the setting of each of the identification reply bits one at a time. Verify proper positioning of these bits, and that the correct bits are present in the reply.

Step 3 Pressure Altitude (Mode S) [§2.2.13.1.2.a (2)]

Connect the transponder RF port to the transponder test set.

a. Interrogate the transponder with a standard surveillance-altitude interrogation (UF=4) with the PC, RR, DI and SD fields set to ZERO and the address the same as that provided to the transponder.

b. With the ALT switch ON, provide altitude code inputs from an altitude source in feet quantised to greater than 25 feet to the transponder which should result in setting each of the AC field bits of the reply, one at a time.

c. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ZERO (0) and the M bit set to ZERO (0).

d. With the ALT switch ON, provide altitude code inputs from an altitude source in feet quantised to 25 feet or less to the transponder and verify that the altitude report is correct as a minimum when the input indicates pressure altitudes of 17050 and 34125 feet.

e. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ONE (1) and the M bit set to ZERO (0).

f. With the ALT switch ON, provide altitude code inputs from an altitude source quantized to 25 feet or less to the transponder. Verify that the altitude report is correct when the input indicates pressure altitudes of between 50188 feet and 126700 feet, which should result in setting each of the AC field bits of the reply.

g. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ZERO (0) to indicate a report to 100 ft quantization and the M bit set to ZERO (0).

h. Verify that the AC field is all ZEROs when the ALT switch is set to “OFF”. Set the input altitude data to invalid and verify that the AC field is all ZEROs.

Step 4 Identification Code (Mode S) (§2.2.13.1.2.b)

With the equipment connected as in Step 3, interrogate the transponder with a standard surveillance-identity interrogation (UF=5) with PC, RR, DI and SD fields set to ZERO (0) and the address the same as that provided to the transponder. Using the identity codes specified in Step 2, verify that the proper bit patterns exist in the ID field of the reply.

Step 5 Flight Status and Vertical Status (§2.2.13.1.2 c and d)

Interrogate with UF=0 and UF=16 and verify that the VS field is a ONE when the "on-the-ground port" of the transponder is set to the on-the-ground condition. Also, verify that the VS field is a ZERO otherwise.

Interrogate with formats UF=4, 5, 20, 21 and verify that the transponder follows the protocol of §2.2.18.2.7 and Figure 2-17.

Step 6 Aircraft Identification Data (§2.2.13.1.2.e)

a. Perform the test procedure provided in §2.6.6.1.a.(1).

b. Perform the test procedure provided in §2.6.6.1.b with the exception that the Test Timer need not be implemented to monitor the “B” timer.

c. Perform the test procedure provided in §2.6.6.5.a.(1).

d. Perform the test procedure provided in §2.6.6.5.b.

2.3.2.11.3 Standard Transaction Interfaces (§2.2.13.3)

Step 1 Uplink Interface Information Content (§2.2.13.3.1.a)

Interrogate the transponder with valid Mode S interrogations of all uplink formats that the transponder is designed to accept. Verify that all fields (possibly excluding AP) of the interrogations are passed correctly through the transponder and except for UF=0, 11, 16, and 24 (when it is a request for a downlink ELM) appear at the uplink interface.

Step 2 Uplink Interface, "No-Storage Design" (§2.2.13.3.1.b)

Interrogate the transponder with valid Mode S interrogations of all uplink formats that the transponder is designed to accept. Verify that all data appear correctly at the uplink interface prior to the start of the transponder reply.

Step 3 Uplink Interface, "Storage Design" Acceptance Rate (§2.2.13.3.1.c)

Interrogate the transponder with valid Mode S interrogations (both short and long) at the rates and time periods specified in §2.2.3.4.2. Verify that all data appear correctly at the uplink interface.

Step 4 Downlink Interface, Information Content (§2.2.13.3.2.a)

Insert an all ONEs input. Interrogate the transponder with all uplink formats that it is designed to accept (one interrogation of each format, RR=16 for long interrogations). Verify that all bits in the transponder replies, not set by transponder protocol requirements, are ONE. Verify that all fields in the replies, set by transponder protocol, have the correct value.

Step 5 Downlink Interface, "No-Storage Design" (§2.2.13.3.2.b)

Insert an all ONEs input. Interrogate the transponder with a standard Comm-A, altitude interrogation. Verify that data are inserted into the transponder at the proper time, and that the transponder reply contains the proper data.

Step 6 Downlink Interface, "Storage Design" Buffer Rate, Buffer Function (§2.2.13.3.2.c)

Set up a sequence of Comm-B replies with the value of the last 48 bits of MB of each reply set to the number of the reply in the sequence (e.g., MB=1 for the first reply). Interrogate the transponder with a standard Comm-A, altitude interrogation at the rates specified for long interrogations in §2.2.3.4. Verify that the replies include the proper data in the MB field. Repeat with RR equal to all valid codes from 16 through 18.

2.3.2.11.4 ELM Service Interfaces (§2.2.13.4)

Connect the transponder RF port to the RF port of the Mode S transponder test set. Connect the Mode S transponder test set of the ELM data link device to the ELM interface port of the transponder and perform the following sequences.

Step 1 ELM Uplink Interface, Data Rate (§2.2.20.1.4)

Interrogate the transponder with four 16-segment uplink ELMs (each segment having unique coding, interrogations spaced 50 microseconds apart, and a new 16 segment ELM starting every 5 milliseconds). After 4 seconds for transponders equipped for standard ELM operation and after 1 second for transponders equipped for enhanced uplink ELM operation, interrogate the transponder with another set of four 16-segment ELMs. Verify that correct data appear at the ELM interface for both interrogation bursts.

Step 2 ELM Downlink Interface, Data Rate (§2.2.20.2.4 and §2.2.3.5)

Set up a downlink ELM which conforms to the maximum capability of the transponder (each segment with unique coding) on the Mode S transponder test set or ELM data link device. Interrogate the transponder with a Comm-C (UF=24) with RC=3 and SRS= "ALL ONEs." Verify that all segments are properly transmitted 136 ±1 microseconds apart.

2.3.2.11.5 Interface Integrity Tests (§2.2.13.2.2)

Specific test procedures for these functions are not described. Detailed procedures for demonstrating compliance with §2.2.13.2.2 are left to the discretion of the manufacturer.

2.3.2.12 Restoration of Power (§2.2.16)

Apply the momentary power interruption sequence appropriate for the transponder environmental category as specified in DO-160G, Section 16. Two seconds after the restoration of power following each power interruption, interrogate the transponder with a Mode S-Only All-Call interrogation with PR, IC and CL fields set to ZERO (0). Verify that a correct All-Call reply (DF=11) is transmitted in response to this interrogation.

2.3.2.13 Acquisition Squitter (§2.2.12.5.1 and §2.2.18.2.6)

a. Establish the appropriate conditions where the transponder is in the airborne state and provides Acquisition Squitter transmissions.

b. Verify that the transponder provides Acquisition Squitter transmissions that:

   1. Are transmitted at average intervals of 0.8 to 1.2 seconds,

   2. Are alternated between the top and bottom antenna for diversity transponders, and

   3. Contain the appropriate message content.

c. Establish the appropriate conditions where the transponder is in the on-ground state and provides Acquisition Squitter transmission.

d. Verify that the transponder provides Acquisition Squitter transmissions that:

   1. Are transmitted at average intervals of 0.8 to 1.2 seconds,

   2. Are transmitted from the top antenna for diversity transponders, and

   3. Contain the appropriate message content.

2.3.2.14 Extended Squitter (§2.2.12.5.2 and §2.2.23)

Step 1 Airborne Position Message Validation (§2.2.12.5.2, §2.2.23.1.3.b)

(1) Establish appropriate conditions where the transponder declares the Airborne State.

(2) Provide the transponder with appropriate latitude, longitude and altitude data via an appropriate interface.

(3) Verify that the transponder provides ADS-B Airborne Position Message Extended Squitter transmissions that:

- are transmitted at average intervals of 0.40 to 0.60 seconds,
- are alternated between the top and bottom antenna for diversity transponder, and
- contain the appropriate information in the "ME" field.

Step 2 Airborne Velocity Message Validation (§2.2.12.5.2, §2.2.23.1.3.e)

(1) Provide the transponder with appropriate velocity data via an appropriate interface.

(2) Verify that the transponder provides ADS-B Airborne Velocity Message Extended Squitter transmissions that:

- are transmitted at average intervals of 0.40 to 0.60 seconds,
- are alternated between the top and bottom antenna for diversity transponders, and
- contain the appropriate information in the "ME" field.

Step 3 Aircraft Identification Message Validation (§2.2.12.5.2, §2.2.23.1.3.d)

(1) Provide the transponder with appropriate aircraft identification data via an appropriate interface.

(2) Verify that the transponder provides ADS-B Aircraft Identification Message Extended Squitter transmissions that:

- are transmitted at average intervals of 4.8 to 5.2 seconds,
- are alternated between the top and bottom antenna for diversity transponders, and
- contain the appropriate information in the "ME" field.

Step 4 Surface Position Message Validation (§2.2.12.5.2, §2.2.23.1.3.c)

(1) Establish appropriate conditions where the transponder declares the On-Ground State.

(2) Provide the transponder with appropriate latitude and longitude data via an appropriate interface.

(3) Verify that the transponder provides ADS-B Surface Position Message Extended Squitter transmissions that:

- are transmitted at average intervals of 4.8 to 5.2 seconds,
- are transmitted on the top antenna only for diversity transponders, and
- contain the appropriate information in the "ME" field.

2.4 Equipment Test Procedures

2.4.1 Definitions of Terms and Conditions of Test

The following definitions of terms and conditions of tests are applicable to the equipment tests specified herein:

a. Power Input Voltage – Unless otherwise specified, all tests **shall** be conducted with the power input voltage adjusted to design voltage ±2 percent. The input voltage **shall** be measured at the input terminals of the equipment under test.

b. Power Input Frequency

(l) In the case of equipment designed for operation from an ac source of essentially constant frequency (e.g., 400 Hz), the input frequency **shall** be adjusted to design frequency ±2 percent.

(2) If the equipment is designed for operation from an ac source of variable frequency (e.g., 300 to 1000 Hz), tests **shall** be conducted with the input frequency adjusted to within five percent of a selected frequency and, unless otherwise specified, within the range for which the equipment is designed.

c. Accuracy of Test Equipment – Throughout this section, the accuracy of the test equipment is not addressed in detail, but rather is left to the calibration process prescribed by the agency which certifies the testing facility.

d. Adjustment of Equipment – The circuits of the equipment under test **shall** be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests. Unless otherwise specified, adjustments may not be made once the test procedures have started.

e. Test Instrument Precautions – During the tests, precautions **shall** be taken to prevent the introduction of errors resulting from the connection of voltmeters, oscilloscopes and other test instruments, across the input and output terminals of the equipment under test.

f. Ambient Conditions – Unless otherwise specified, all tests **shall** be conducted under conditions of ambient room temperature, pressure and humidity. However, the room temperature **shall not** be lower than 10 degrees C.

g. Connected Loads – Unless otherwise specified, all tests **shall** be performed with the equipment connected to loads having the impedance values for which it is designed.

h. Standard Interrogation Test Signals

The signal measurement convention **shall** be as specified in §2.1.11.

(l) General Characteristics

(a) Radio Frequency: The carrier frequency of the signal generator for ATCRBS and ATCRBS/Mode S All-Call interrogation **shall** be 1030 ±0.1 MHz. Mode S interrogation signals **shall** have a carrier frequency of 1030 ±0.01 MHz.

(b) CW Output: The CW output between pulses **shall** be at least 50 dB below the peak level of the pulse.

(c) Pulse Rise and Fall Time: Rise and fall times **shall** be as specified in §2.1.11.3.1 and §2.1.11.4.1.

Note: *Unless otherwise indicated, interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector.*

(d) Pulse Top Ripple: The instantaneous amplitude of the pulses **shall not** fall more than l dB below the maximum value between the 90 percent voltage amplitude point on the leading and trailing edge of the pulse.

(e) Signal Level: Unless otherwise noted in the measurement procedure, the signal level **shall** be -60 ±3 dBm.

(f) Interrogation Repetition Standard Rate: Unless otherwise noted in the measurement procedure, interrogation rates **shall** be 450 ±25 Hz for ATCRBS interrogations and 45 ±5 Hz for All-Call and Mode S interrogation.

(g) Mode S Interrogation Address: Unless otherwise noted in the measurement procedure, the transponder address encoded in a Mode S interrogation **shall** be: Hexadecimal-AA AAAA, (i.e., binary 1010 1010 1010 1010 1010 1010).

(2) ATCRBS, ATCRBS/Mode S All-Call and ATCRBS-Only All Call Interrogations

The nominal characteristics **shall** be as specified in §2.1.11.3.

(3) Mode S Interrogations

The nominal characteristics **shall** be as specified in §2.1.11.4.

(a) Standard Mode S-Only All-Call Interrogation: Standard Mode S - Only All-Call interrogation is defined as a Mode S interrogation with UF=11, PR=8, IC and CL=0. An address of 24 ONEs is used in generation of the AP field.

(b) Standard Mode S Surveillance – Altitude Interrogation: Standard Mode S Surveillance Altitude Interrogation is defined as a Mode S interrogation of uplink format 4 (UF=4, Figure 2-5) with the following mission field values:

PC=0
RR=0
DI=0
SD=0

(c) Standard Mode S Surveillance – Identity Interrogation: Standard Mode S Surveillance – Identity Interrogation is defined as a Mode S interrogation of uplink format 5 (UF=5, Figure 2-5) with the following mission field values:

PC=0
RR=0
DI=0
SD=0

(d) Standard Comm-A – Altitude Interrogation: Standard Comm-A – Altitude Interrogation is defined as a Mode S interrogation of uplink format 20 (UF=20) with the following mission field values:

PC=0
RR=20
DI=0
SD= all ONEs
MA=hexadecimal - AA AAAA AAAA AAAA

i. Mode S Transponder Test Set

The Mode S transponder test set referenced in the detailed test procedures section is assumed to have the following minimum capabilities:

(1) Means of varying RF frequency by at least 60 MHz from center frequency.

(2) Means of varying the amplitude of the interrogating signal level from at least -21 to -85 dBm.

(3) Means of varying the amplitude of either P_2, P_3 or P_4 with respect to P_1.

(4) Means of measuring the number of correct replies transmitted in response to valid interrogations.

(5) Means of varying interval spacings between the following pairs of pulses: P1 - P_2, P1 - P_3 and P_3- P_4.

(6) Means of independently varying the durations of P_1, P_2, P_3 and P_4.

(7) Means of selecting ATCRBS Mode A or Mode C, ATCRBS/Mode S All-Call, ATCRBS-Only All-Call or Mode S interrogation formats.

(8) Means of providing carrier phase modulation of the P_6 pulse.

(9) Means of selecting the data which will modulate the P_6 pulse.

(10) Means to display the downlink reply bit pattern generated by the unit under test in response to a Mode S or All-Call interrogation.

(11) Means of adding a single 0.8 microsecond wide pulse or 0.8 microsecond pulse pairs spaced 2.0 microseconds apart, with level adjustable from 12 dB below P_1 to equal with P_1 at a carrier frequency of 1030.0, +0.2 MHz, incoherent with the Mode S signal frequency, with the following characteristics:

(a) Repetition frequencies variable up to 10000 Hz.

(b) Positionable anywhere from the first pulse coincident with P_1 to the second pulse coincident with the end of P_6.

(12) Means to synchronize interrogation repetitions with a like test set.

(13) Means to rapidly change between two interrogation rates.

(14) Means to move the sync phase reversal position in P_6 over a +200 nanosecond range from assigned position.

(15) Means of encoding Mode S interrogations with proper parity check sequence.

(16) Means of decoding Mode S replies using proper parity check sequence.

(17) Means for interlacing ATCRBS and Mode S interrogations.

(18) Means of generating ATCRBS and Mode S burst rates in accordance with §2.2.3.4.

(19) Means of adding single 6.4 ±0.5-microsecond pulses or 3.5 ±0.5-microsecond pulse pairs spaced either 12 ±0.5 or 30 ±0.5 microseconds apart. The level **shall** be set at -30 dBm at a carrier frequency variable from 962 to 1213 MHz. The repetition rate on the pulse pairs **shall** be variable up to 3600 Hz and on the single pulses up to 2000 Hz.

2.4.2 Detailed Test Procedures

The test procedures set forth below are considered satisfactory for use in determining required performance under standard and stressed conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred by the testing facility. These alternate procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

For more detailed procedures regarding digital data, see §2.5.

2.4.2.1 Receiver Characteristics (§2.2.2)

Equipment Required:

ATC Test Set with P_4 Capability (TIC T-50-3A/4B, or equivalent)

Measurement Procedure:

With the equipment connected as shown in Figure 2-34, interrogate the transponder with a standard Mode A interrogation and follow Steps l through 4 below.

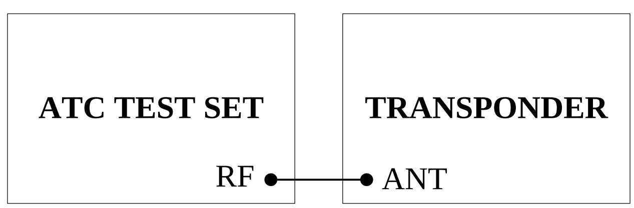


Figure 2-34: **Test Equipment Connection**

Note: *The power can be measured either at the antenna or at the LRU (if corrections for cable loss are included).*

Step 1 Sensitivity Variation with Frequency (§2.2.2.2)

Vary the RF signal frequency over the range 1029.8 to 1030.2 MHz. Use a frequency increment that includes 1030.0 MHz. Determine the variation in RF signal level that is required to produce 90 percent transponder reply efficiency. Also determine the required maximum RF signal level.

Step 2 Sensitivity (§2.2.2.4 a and e)

Connect the equipment as shown in Figure 2-34. Interrogate the transponder with a standard Mode A interrogation. Determine the minimum RF signal level required to produce 90 percent transponder reply efficiency. Repeat the procedure using a standard Mode A ATCRBS/Mode S All-Call interrogation and a standard Mode C ATCRBS/Mode S All-Call interrogation. Determine MTL for all cases. This is the ATCRBS MTL.

Step 3 ATCRBS and ATCRBS/Mode S All-Call Dynamic Range (§2.2.2.4.f)

Repeat Step 2 for RF levels in 5 dB intervals between MTL +3 dB and -21 dBm. Determine reply ratio.

Step 4 Bandwidth (§2.2.2.3)

Adjust the RF signal level to 60 dB above MTL. Determine the frequencies above and below 1030 MHz at which 90 percent transponder reply efficiency is obtained.

Note: *Care must be taken to avoid high signal levels at or near center frequency.*

Step 5 ATCRBS and ATCRBS/Mode S All-Call Low-Level Reply Ratio (§2.2.2.4.d)

Repeat Step 2 for an RF level of -81 dBm. Determine reply ratio.

Note: *The following steps require the use of test equipment having the capabilities set forth in §2.4.1.i.*

Step 6 Mode S (§2.2.2.4.b)

Interrogate the transponder with a Mode-S Only All-Call interrogation at a standard rate with PR=0. Determine the minimum RF level to produce 90 percent proper reply efficiency.

Step 7 Mode S Dynamic Range (§2.2.2.4.c)

Using the signal specified in Step 6, determine the reply efficiency for RF levels between MTL +3 dB and -21 dBm; use 5 dB steps.

Step 8 Mode S Low-Level Reply Ratio (§2.2.2.4.d)

Using the signal specified in Step 6, determine reply efficiency for an RF level of -81 dBm.

Step 9 Spurious ATCRBS Replies to Low Level Mode S Interrogations (§2.2.2.4.g)

Use the following three input interrogations:

1. UF4 with PC=4; RR=12; DI=3; SD=4924; AP=AAAAAA;
2. UF20 with PC=4; RR=12; DI=3; SD=4924; MA=49249249249249; AP=AAAAAA;
3. UF20 with PC=4; RR=12; DI=3; SD=9000; MA=90009000900090; AP=AAAAAA;

a. Connect the transponder suppression output to a frequency counter (Fluke 7220A or similar).

b. Set the frequency counter resolution to 1 Hz.

c. Set the transponder address to any valid address other than AAAAAA in order to prevent Mode-S reply.

d. Turn off transponder squitter replies.

e. Interrogate at a rate of 100 PRF between -81dBm and the Mode-S MTL with the interrogations shown above, using 1 dB steps. In order to include the Mode-S MTL as the last test point, the last step may be smaller than 1 dB.

f. Frequency counter will display ATCRBS reply rate.

g. Take the average of 10 frequency counter readings at each power level between -81 dBm and the Mode-S MTL. Verify that the average reply rate is no more than 1% ATCRBS replies averaged over the range between –81 dBm and the MTL for interrogation “1” above, and no more than 3% ATCRBS replies at any power level between –81 dBm and the MTL.

h. Repeat Steps “e,” “f” and “g” above, except that you interrogate using power levels between -80.5 dBm and the Mode-S MTL, in 1 dB steps, with interrogation “2” above. This offsets the test by 0.5 dB in order to ensure that the sensitivity to signal level is checked.

i. Repeat Steps “e,” “f” and “g” above, except that you interrogate using interrogation “3” above.

2.4.2.2 Transmitter Characteristics (§2.2.3)

2.4.2.2.1 Reply Transmission Frequency (§2.2.3.1)

Equipment Required:

ATC Test Set with P_4 capability (TIC T-50-3A/4B, or equivalent).
Stub Tuner (Microlab/FXR Sl-05N, or equivalent).
Variable Air Line (Line Stretcher) (Microlab/FkR SR-05N, or equivalent).
Slotted Line (HP 805C, or equivalent).

Measurement Procedure:

Connect the equipment as shown in Figure 2-35. Adjust the stub to establish a 1.5:1 VSWR at the antenna end of the coax line specified by the manufacturer. If the transponder requires a minimum length of a specified cable type, an attenuator equal to the loss of the minimum amount of cable may be placed between the 1.5:1 VSWR point and the transponder antenna jack. Alternately, a length of cable equal to the specified minimum length and cable type may be used in lieu of the attenuator. Interrogate the transponder with a standard Mode A interrogation and adjust the line stretcher to determine the maximum and minimum transmitter frequency. Use a 14 (7777) pulse reply group. Repeat the above procedure with a standard Mode A ATCRBS/Mode S All-Call at standard rate only. Determine that the frequency shift does not exceed the requirements of §2.2.3.1.

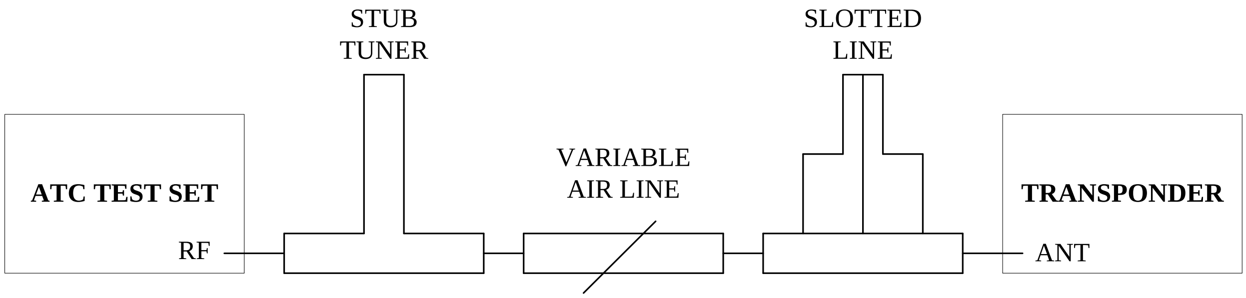


Figure 2-35: Test Equipment Connection

2.4.2.2.2 RF Peak Power Output (§2.2.3.2)

Equipment Required:

ATC Test Set with P_4 capability (TIC T-50-3A/4B, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step l ATCRBS Power Output (§2.2.3.2)

Connect the equipment as shown in Figure 2-31. Set the transponder for a 14 (7777) pulse reply. Interrogate the transponder with a standard Mode A interrogation and measure the single pulse having the least RF power output. While varying the interrogation rate from 100 interrogations per second to the maximum interrogation rate specified for the transponder, determine that the power output meets the requirements of §2.2.3.2.

Repeat the procedure measuring the single pulse having the most RF power output.

Step 2 Short Mode S Power Output (§2.2.3.2)

Repeat Step 1 with a standard Mode A ATCRBS/Mode S All-Call interrogation at standard rate only.

Step 3 Long Mode S Power Output

For transponders with long reply capability (Level 2 or above), repeat Step 1 with sixteen Mode S interrogations per second using any format and coding for which a long reply is required.

If the transponder is also Extended Squitter capable, then configure the transponder so that the transponder is transmitting the Extended Squitters (or an equivalent number of long replies) in addition to the sixteen replies.

Step 4 Extended Long Mode S Power Output (§2.2.3.5)

For transponders with extended reply capability (Level 4 or above), repeat Step 3, stimulating the maximum rate of long replies for which the transponder is designed.

Note: *The reply rate capability has to take into account 25% surplus transmitting capability. (e.g., if the transponder has declared the capacity to deliver the maximum of **N** ELM segments per second, it has to deliver **N** + 25% of **N** in a 25-millisecond interval of each second as defined in §2.2.3.5).*

2.4.2.2.3 Unwanted Power Output (§2.2.3.3 and §2.2.22.f)

Equipment Required:

Test Set with Mode S capability.
Spectrum Analyzer (HP 8535A, or equivalent).
Directional Coupler (HP 796D, or equivalent).

Note: *For test equipment protection, the transponder transmitter modulation may be disabled by external means.*

Measurement Procedure:

Connect the equipment as shown in Figure 2-36. Do not interrogate the transponder. Measure the RF output power between squitter transmission periods.

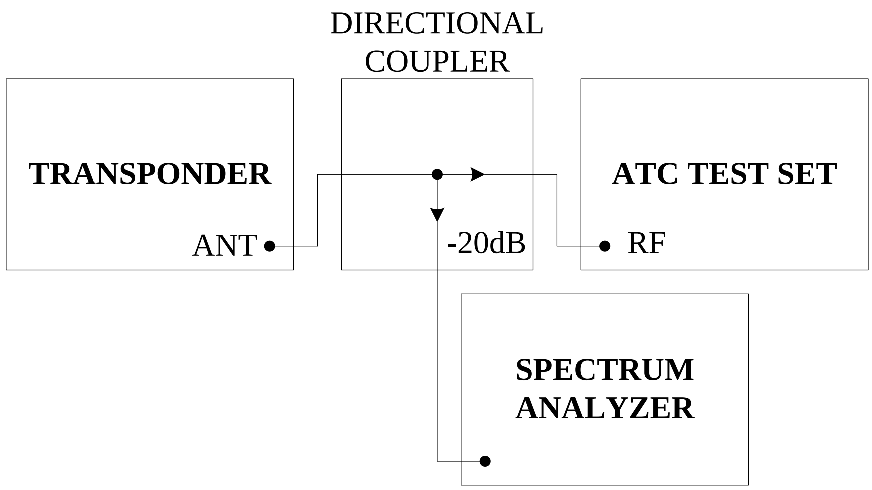


Figure 2-36: Test Equipment Connection

2.4.2.2.4 Reply Rate Capability

Equipment Required:

Mode S Transponder Test Set.

Measurement Procedure:

Step l Continuous Reply Rate Capability (§2.2.3.4.1.a and §2.2.3.4.2)

Set the transponder for a 15-pulse ATCRBS reply. Interrogate the transponder at a constant rate of 500 ATCRBS interrogations per second plus 50 Mode S interrogations (with short replies) per second. Determine reply ratio for each type of interrogation. Measure the output power and frequency. If the transponder is equipped for long Mode S reply formats, repeat the test with 16 (24 if also equipped with the enhanced data link protocols) of the 50 Mode S interrogations requiring long replies.

Step 2 100 Milliseconds Peak Reply Rate Capability (§2.2.3.4.1 b & c and §2.2.3.4.2)

Set the transponder for a 15-pulse ATCRBS reply. Interrogate the transponder with periodic bursts of ATCRBS and Mode S interrogations as follows: 120

ATCRBS interrogations (100 for Class 2 equipment) plus 18 Mode S interrogations (with short replies), each type of interrogation approximately uniformly spaced within a single 0.1-second interval, followed by a 0.9-second interval with no interrogations. Determine reply ratio for each type of interrogation. Measure the output power and frequency. If the transponder is equipped for long Mode S reply formats, repeat the test with 6 (9 if also equipped with the enhanced data link protocols) of the 18 Mode S interrogations requiring long replies.

Step 3 25 Millisecond Peak Reply Rate Capability (§2.2.3.4.2)

Set the transponder for a 15-pulse ATCRBS reply. Interrogate the transponder with periodic bursts of ATCRBS and Mode S interrogations as follows: 30 ATCRBS interrogations (25 for Class 2 equipment) plus eight Mode S interrogations (requiring short replies), each type of interrogation burst approximately uniformly spaced within a single 25-millisecond interval, followed by a 975-millisecond interval without interrogations. Determine reply ratio for each type of interrogation. Measure output power and frequency. If the transponder is equipped for long Mode S reply formats, repeat the test with 4 (6 if also equipped with the enhanced data link protocols) of the 8 Mode S interrogations requiring long replies.

Step 4 1.6 Milliseconds Peak Reply Rate Capability (§2.2.3.4.1 and §2.2.3.4.2)

Repeat Step 3 with the following modification:

Use two ATCRBS interrogations plus four Mode S interrogations (with short replies), each type of interrogation approximately uniformly spaced within a single l.6-millisecond interval, followed by a 998.4-millisecond interval with no interrogation. Determine reply ratio for each type of interrogation. Measure output power and frequency. If the transponder is so equipped repeat the test with two of the four Mode S interrogations having long replies.

2.4.2.2.5 ATCRBS Reply Rate Limiting (§2.2.7.3.1)

Equipment Required:

ATC Test Set (T-50-3A/4A (2 required), or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
Frequency Counter (HP 5381A, or equivalent).

Measurement Procedure:

Connect the equipment as shown in Figure 2-32 and Figure 2-37.

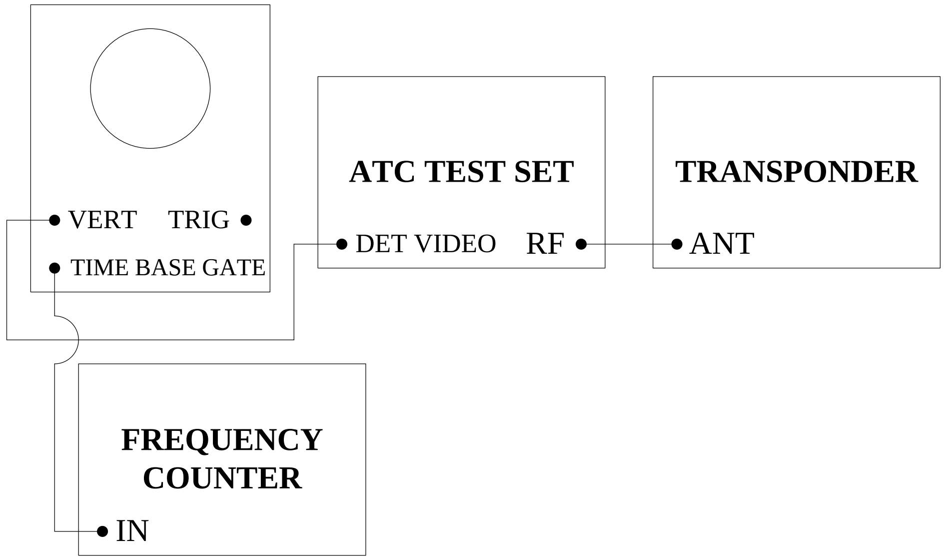


Figure 2-37: Test Equipment Connection

Step 1 Determination of Reply Rate Limit

Set the Mode A code to 0000. Interrogate the transponder on Mode A with a signal 20 dB above MTL at a variable rate starting at 500 per second. Gradually increase the interrogation rate while observing the reply count over 1-second intervals. The highest count observed is the reply rate limit. Verify that it does not exceed 2000 continuous replies per second.

Step 2 Sensitivity Reduction

Set the transponder's Mode C code to 0000 and its Mode A code to any value other than 0000. Interrogate the transponder with the sum of a) a Mode C interrogation 20 dB above MTL at a continuous rate equal to the reply rate limit determined in Step 1 and b.) a second unsynchronized Mode A interrogation 3 dB above MTL at a continuous rate equal to 50% of the reply rate limit determined in Step 1. Verify that the transponder replies to at least 90% of the interrogations at the signal level 20 dB above MTL and that it does not reply to more than 10% of the interrogations at the signal level 3 dB above MTL.

2.4.2.3 Reply Pulse Characteristics

2.4.2.3.1 ATCRBS Reply Pulse Characteristics (§2.2.4.1)

Equipment Required:

ATC Test Set (TIC T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step 1 ATCRBS Reply Pulse Spacing (§2.2.4.1.1, §2.2.4.1.2, §2.2.4.1.5)

Connect the equipment as shown in Figure 2-31. Interrogate with a standard Mode A interrogation. Use a 14-pulse reply group (7777) and display the transmitted pulses on the wide band oscilloscope. Measure the spacing of each transmitted pulse with respect to the first framing pulse and the spacing between information pulses.

Step 2 ATCRBS Reply Pulse Shape (§2.2.4.1.4)

Using a standard ATCRBS Mode A interrogation, measure the duration of each reply pulse. Measure rise and decay times of each pulse. Measure the pulse amplitude variations of each pulse with respect to all other pulses in the reply train.

CAUTION: *If the detector is not known to be linear, checks should be made to determine what amplitude points on the detected pulse correspond to the 10 percent and 90 percent amplitude points of the RF pulses.*

In addition, checks should be made to determine the rise time of the detector.

Step 3 SPI Pulse (§2.2.4.1.3, §2.2.4.1.4 and §2.2.4.1.5)

Momentarily activate the SPI pulse control. Interrogate the transponder with a standard ATCRBS Mode-A interrogation. Measure the position of the SPI pulse with respect to the last framing pulse and the time the pulse remains in the reply train. Measure the width of the SPI pulse. With the SPI pulse activated, interrogate the transponder with a standard ATCRBS Mode-C interrogation. Verify that the SPI pulse is not present in the reply train.

2.4.2.3.2 ATCRBS Reply Delay and Jitter (§2.2.4.1.6)

Equipment Required:

ATC Test Set (TIC T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step l Reply Delay (§2.2.4.1.6.a)

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard Mode A interrogation. Synchronize the oscilloscope using the leading edge of P_3.

Measure the average delay between the leading edge of P_3 and the leading edge of the first reply pulse at the 50 percent amplitude points when the signal level is varied in increments of 5 dB between minimum triggering level and -21 dBm.

Step 2 Reply Jitter (§2.2.4.1.6.b)

Repeat Step l measuring the extreme positions of the leading edge of the first reply pulse at the various signal levels from 3 dB above minimum triggering level to -21 dBm.

Step 3 Reply Delay Variation (§2.2.4.1.6.c)

Repeat Step l using alternate Mode C and Mode A interrogations. Use signal levels from MTL +3 dB to -21 dBm. Measure the reply delay variation between modes.

2.4.2.3.3 Mode S Replies (§2.2.4.2)

Equipment Required:

ATC Test Set with P_4 Capability (TIC T-50-3A/4B, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step l Mode S Preamble (§2.2.4.2.1)

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard Mode A ATCRBS/Mode S All-Call. Display the Mode S reply on the oscilloscope. Measure the pulse duration of the first four reply pulses. Measure pulse spacing between the leading edge of the first and each of the second, third and fourth pulses.

Step 2 Mode S Reply Data Pulses (§2.2.4.2.2)

Note: *For Steps 2 through 6, examine pulses at the beginning, middle and end of the replies.*

Connect equipment as in Figure 2-31. Measure the pulse duration for both short and long reply pulses throughout the Mode S reply.

Measure the pulse spacing of the fifth reply pulse with reference to the first reply pulse.

Step 3 Mode S Reply Amplitude Variation (§2.2.4.2.3.a)

Connect the equipment as in Figure 2-31. Measure the maximum power differential between pulses in the Mode S reply.

Step 4 Mode S Reply Pulse Shape (§2.2.4.2.3.b)

Measure the rise time of the reply pulses.

CAUTION: *If the detector is not known to be linear, checks should be made to determine what amplitude points on the detected pulse correspond to the 10 percent and 90 percent amplitude points of the RF pulses. In addition, checks should be made to determine the rise and decay time of the detector.*

Step 5 Mode S Reply Pulse Shape (§2.2.4.2.3.c)

Repeat the measurement for decay time.

Step 6 Mode S Reply Pulse Spacing Tolerance (§2.2.4.2.4)

Connect equipment as in Figure 2-31. Determine that the leading edge of any reply pulse is within 50 nanoseconds of its assigned position.

Step 7 Mode S Reply Delay and Jitter (§2.2.4.2.5.a)

Interrogate the transponder with a standard Mode S interrogation using any format for which a reply is required. Synchronize the oscilloscope to the interrogation. Measure the extreme positions of the leading edge of the first reply pulse, when the signal level is varied between 3 dB above the MTL and -21 dBm; and the delay between the P_6 sync phase reversal transient and the leading edge of the first reply pulse.

Step 8 ATCRBS/Mode S All-Call Reply Delay and Jitter (§2.2.4.2.5.b)

Interrogate the transponder with a standard ATCRBS/Mode S All Call interrogation. Synchronize the oscilloscope to the interrogation. Measure the extreme positions of the leading edge of the first reply pulse, when the signal level is varied between 3 dB above the MTL and -21 dBm; and the delay between the leading edge of P_4 and the leading edge of the first reply pulse.

2.4.2.3.4 Frequency Spectrum of Mode S Replies (§2.2.4.2.3.d)

Equipment Required:

Test Set with Mode S capability.
Spectrum Analyzer (HP 8535A, or equivalent).
Directional Coupler (HP 796D, or equivalent).

Measurement Procedure

Connect the equipment as shown in Figure 2-36. Set the transponder to the 7777 identification code. Interrogate the transponder with a standard Mode S surveillance-identity interrogation and observe the spectral response of the reply.

2.4.2.4 Side Lobe Suppression (§2.2.5 and §2.2.8.5)

Equipment Required:

ATC Test Set [T-50-3A/4A (2 required), or equivalent].
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
3 Port Divider (Weinschel 1506, or equivalent).

Measurement Procedure:

Step 1 SLS Decoding [§2.2.5.1.a (1) and (3), §2.2.5.1.b and §2.2.8.5]

Connect the equipment as shown in Figure 2-32. Interrogate the transponder with a standard Mode A interrogation including a P_2 pulse. RF signal level to be at MTL +3 dB; P_2 level = P_1 level. As the P_1 - P_2 spacing is varied over 1.0 to 3.0 microseconds, determine the reply efficiency. Adjust the P_1 - P_2 spacing to the nominal value and insert a 0.8 microsecond pulse (equal in amplitude to P_1 and P_2) such that it occurs 8 microseconds before P_2. Repeat with a 21-microsecond spacing between the inserted pulse and P_2. Verify that the reply ratio is no more than 1 percent.

Step 2 SLS Dynamic Range [§2.2.5.1.a (2) and §2.2.5.1.c]

Repeat Step 1 at RF signal levels: -60 dBm, -40 dBm and -21 dBm.

Step 3 SLS Pulse Ratio (§2.2.5.1.b)

Repeat Step 1 at RF signal levels between MTL +3 dB, (-60 dBm, -40 dBm and -21 dBm). Set P_2 level 9 dB below P_1 level.

Step 4 SLS Pulse Ratio (§2.2.5.1 a and b)

Repeat Steps 1, 2 and 3 with an ATCRBS Mode A/Mode S All-Call interrogation (retaining the 8-microsecond spacing between P_1 and P_3, and add P_4).

Step 5 Suppression Duration [§2.2.5.1.d (l)]

Interrogate the transponder at 450 interrogations per second with a P_1 - P_2 pulse pair, followed after 50 microseconds by a P_1 - P_3 (Mode A, 8 microseconds) pulse pair. The interrogation level **shall** be set at -24 dBm, reply code selection is not consequential. Reduce the spacing of the P_1 - P_3 pair with respect to the P_1 - P_2 pair until the transponder replies to no more than 1% of the interrogations. The time interval between the leading edges of P_2 and P_1 (of the P_1 - P_3 pair) is the suppression duration S(8).

Repeat above procedure using Mode C (21-microsecond spacing) for the P_1 - P_3 pair. The result will be suppression duration S(21).

Step 6 Suppression Reinitiation [§2.2.5.1.d (3)]

Connect the equipment as shown in Figure 2-32. With an interrogation rate of 450 interrogations per second, generate a "first" P_1 - P_2 pair followed by a "second" P_1 - P_2 pair such that the spacing between P_2 of the first pair and P_1 of the second pair is S(8) +2 microseconds. Generate a “third” pair, P_1 - P_3, Mode A to follow the second pair after 50 microseconds. All pulse levels **shall** be set to -24 dBm; reply code is inconsequential. Reduce the spacing of the P_1 - P_3 pair in respect to the P_1 - P_2 pairs and determine suppression duration S(8) as in Step 4. Repeat the test using Mode C spacing for the P_1 - P_3 pair and determine suppression duration S(21).

Step 7 Recovery After Suppression [§2.2.5.1.d (4)

Repeat Step 5 using the following signal levels: P1 - P_2 pair: -30 dBm; P1 - P_3 pair: MTL. A reply efficiency of 90 percent should be observed when the P_2 (suppression) P_1 (interrogation) spacing is no more than one microsecond greater than S(8, 21) determined in previous steps.

Step 8 Low Signal Level Characteristics (§2.2.5.1.c)

Interrogate the transponder with a Mode A interrogation, including a P_2 pulse (P_2=P_1 level). Vary the signal level from MTL to MTL +3 dB. Verify that the reply ratio does not exceed 10%.

Step 9 Short Duration P_2 (§2.2.5.1.b.(3))

Interrogate the transponder with a Mode A interrogation with:

(1) P_2 level = P_1 level

(2) P_2 duration less than 0.3 µs

Record the reply ratio and verify the minimum is at least 90% at signal levels of MTL +3dB, -50 and -21 dBm.

2.4.2.5 Pulse Decoder Characteristics (§2.2.6)

Equipment Required:

ATC Test Set with P_4 Capability (TIC T-50-3A/4B, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
Mode S Transponder Test Set (Required for Steps 8 through 10).

Measurement Procedure:

Step 1 Pulse Level Tolerances, ATCRBS/Mode S All-Call (§2.2.6.1.1)

Connect the equipment as shown in Figure 2-31. Interrogate at the standard rate and at an input level 10 dB above MTL. Use an ATCRBS Mode A interrogation followed by a 1.6-microsecond P_4 pulse in its nominal position. Vary the level of the P_4 pulse between -10 and 0 dB with respect to P_3. Verify the changeover from ATCRBS to Mode S replies at the relative P_4 levels specified in §2.2.6.1.1.a and b when more than 90% of the replies are Mode S or ATCRBS.

Repeat the test at input signal levels -60, -40 and -21 dBm. Repeat the tests using an ATCRBS Mode C interrogation.

Step 2 Pulse Level Tolerances, ATCRBS-Only All-Call (§2.2.6.1.2)

Use setup and signal levels as in Step 1 above but employ a 0.8 microsecond P_4. Vary the level of the P_4 pulse between -10 and 0 dB with respect to P_3. Verify the changeover from ATCRBS replies to no replies at the relative P_4 levels specified in §2.2.6.1.2.a and b.

Repeat the test at input signal levels -60, -40 and -21 dBm. Repeat the tests using an ATCRBS Mode C interrogation.

Step 3 Pulse Position Tolerances, $P_{1/3}$, ATCRBS-Type Interrogations (§2.2.6.2 a and b)

Use setup and signal levels as in Step l above. Interrogate with:

a. ATCRBS Mode A.
b. ATCRBS Mode C.
c. ATCRBS Mode A/Mode S All-Call.
d. ATCRBS Mode C/Mode S All-Call.
e. ATCRBS Mode A-Only All-Call.
f. ATCRBS Mode C-Only All-Call.

For each interrogation type vary the P_1 - P_3 spacing first within the required acceptance range (§2.2.6.2 a) and verify that the reply ratio is at least 90 percent. Then vary the P_1 - P_3 spacing to fall out of the permitted acceptance range (§2.2.6.2.b) and verify that not more than 10 percent of the replies are generated. There **shall not** be any replies to either of the ATCRBS-Only All-Call modes.

Step 4 Pulse Position Tolerances, P_4, ATCRBS/Mode S All-Calls (§2.2.6.2 a and c)

Use setup and signal levels as in Step 1 and interrogate with:

a. ATCRBS Mode A/Mode S All-Call.
b. ATCRBS Mode C/Mode S All-Call.

For both interrogation types, vary the P_3 - P_4 spacing first within the required acceptance range and then beyond the permitted acceptance range. Determine conformance to requirements as in Step 3.

Step 5 Pulse Duration Tolerances, ATCRBS Interrogations (§2.2.6.3 a and b)

Use setup and signal levels as in Step 1 above and interrogate with:

a. ATCRBS Mode A.
b. ATCRBS Mode C.

For both interrogation types, vary the P_1 duration first within the acceptance range (§2.2.6.3.a) and then beyond the acceptance range (§2.2.6.3.b). Verify reply ratio. Repeat test varying the P_3 duration in the same manner.

Step 6 Pulse Duration Tolerance, ATCRBS/Mode S All-Call (§2.2.6.3 a and b)

Use setup and signal levels as in Step 1 above and interrogate with:

a. ATCRBS Mode A/Mode S All-Call.
b. ATCRBS Mode C/Mode S All-Call.

For both interrogation types vary the P_1 duration first within the acceptance range (§2.2.6.3.a) and then beyond the acceptance range (§2.2.6.3.b). Verify reply ratio. Repeat test varying the P_3 duration in the same manner. Repeat test varying the P_4 in the same manner.

Step 7 Short Pulse Rejection, ATCRBS-Type Interrogations (§2.2.6.3.c)

Use setup as in Step 1 and set signal input level to MTL for each of the following interrogation types:

a. ATCRBS Mode A.
b. ATCRBS Mode C.
c. ATCRBS Mode A/Mode S All-Call.
d. ATCRBS Mode C/Mode S All-Call.

For each interrogation type vary the P_1 duration between 0.2 and 0.7 microsecond and verify that less than 10 percent of the replies are generated when the pulse has less than 0.3 microsecond duration. Repeat test varying the P_3 duration in the same manner. Repeat tests at 5 dB increments up to -45 dBm input level.

Step 8 Sync Phase Reversal Position Tolerance (From P_2) (§2.2.6.4)

Set the Mode S test set to generate a standard Mode S-Only All-Call interrogation at MTL +3 dB. Vary the spacing between the leading edge of P_2 and the P_6 sync phase reversal transient by ±200 nanoseconds from the nominal 2.75 microseconds. Measure the range over which Mode S replies are received. Repeat for P_1 levels between -50 dBm and -21 dBm in 5 dB steps.

Note: *Steps 8 and 9 require the Mode S Transponder Test Set.*

Step 9 Sync Phase Reversal Position Tolerance (From P_6) (§2.2.6.4)

Set the Mode S test set to generate a standard Mode S-Only All-Call interrogation at MTL +3 dB. Vary the spacing between the leading edge of P_6 and the P_6 sync phase reversal transient by ±200 nanoseconds from the nominal 1.25 microseconds. Measure the range over which Mode S replies are received. Repeat for P_1 levels of -50 dBm and -21 dBm in 5 dB steps.

Note: *Either Step 8 or Step 9 is to be used, depending on the design of the transponder.*

Step 10 Simultaneous Interrogations (§2.2.8.5)

Use setup, signal levels, and formats as in Step 5 above and insert a 0.8 microsecond pulse (equal in amplitude to P_1 and P_3) such that it occurs 8 microseconds before the P_3 pulse of a Mode C interrogation. Observe that all replies are Mode C replies.

2.4.2.6 Transponder Desensitization and Recovery (§2.2.7)

Equipment Required:

ATC Test Set [TIC T5OA-3A/4A (2 required), or equivalent].
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
3 Port Power Divider (Weinschel 1506, or equivalent).
Mode S Transponder Test Set.

Measurement Procedure:

Step 1 ATCRBS Single Pulse Desensitization and Recovery (§2.2.7.1.1 and §2.2.7.2)

Connect the equipment as shown in Figure 2-32. Set the master test set to generate a single pulse not less than 0.7 microseconds wide at the standard ATCRBS interrogation rate and a power level equal to 50 dB above MTL. Set the slave test set to generate an ATCRBS Mode A interrogation delayed three (3) microseconds from the trailing edge of the single pulse. Determine the amplitude of the slave test set signal required to produce 90 percent reply efficiency. Repeat for master to slave test set delays of 6, 10 and 15 microseconds.

Note: *Steps 2 through 7 require replacement of one of the ATC test sets by a Mode S transponder test set.*

Step 2 Recovery from a Mode S Interrogation Requiring No Reply (§2.2.7.2.1)

With the equipment connected as shown in Figure 2-32, set the master test set to generate a short Mode S surveillance interrogation with broadcast address. Set the slave test set to generate an ATCRBS Mode A interrogation at a power level equal to 3 dB above MTL. Measure the delay time between the master and the slave test sets necessary to elicit a reply efficiency of 90%.

Step 3 Recovery from a Mode S Comm-C Interrogation (§2.2.7.2.1)

With equipment connected as shown in Figure 2-32, set the master set to generate the initial segment of a properly addressed Comm-C interrogation at a signal level of -21 dBm. Set the slave test set to generate an ATCRBS Mode A interrogation delayed 45 microseconds from the sync phase reversal of the master interrogation. Determine the amplitude of the slave test signal required to produce 90 percent reply efficiency.

Step 4 Recovery from a Suppression Pair or ATCRBS-Only All-Calls or Unaccepted ATCRBS/Mode S All-Call (§2.2.7.2.2 and §2.2.7.2.4)

With equipment connected as shown in Figure 2-32, set the master test set to generate a P_1 - P_2 pulse pair at the ATCRBS standard interrogation rate and a power level equal to -35 dBm. Set the slave test set to generate a Mode S-Only All-Call interrogation delayed 10 microseconds from the trailing edge of the P_2 pulse of the master test set interrogation. Determine the amplitude of the slave test set signal required to produce 90% reply efficiency.

Repeat the procedure with an ATCRBS-Only All-Call in place of the suppression pair. Set the Mode S-Only All-Call from the slave test set delayed 10 microseconds from the trailing edge of the P_4 pulse of the master test set interrogation.

Lock out transponder to All-Calls (non-selective) and repeat procedure with ATCRBS/Mode S All-Call interrogations in place of the suppression pair. Set the II field of the Mode S-Only All-Call to a value other than ZERO (0) so that it will not be affected by the lock-out condition.

Step 5 Narrow Pulse Performance (§2.2.7.1.2)

With the equipment connected as shown in Figure 2-32, set the master test set to generate a single pulse less than 0.7 microseconds wide at the standard ATCRBS interrogation rate and a power level equal to 50 dB above MTL. Set the slave test set to generate an ATCRBS Mode A interrogation delayed three (3) microseconds from the trailing edge of the single pulse. Determine the amplitude of the slave test set signal required to produce 90 percent reply efficiency. Repeat for master to slave test set delays of 6, 10 and 15 microseconds.

Step 6 Dead Time (§2.2.7.2.5)

With the equipment connected as shown in Figure 2-32, set the master test set to generate an ATCRBS Mode A interrogation at a level of -21 dBm. Set the slave test set to generate a Mode S-Only All-Call interrogation at a level of 3 dB above MTL. Determine the time delay between the end of the reply to the master interrogation and the start of the slave interrogation that elicits a 90 percent reply efficiency from the transponder. Repeat with the master test set generating a Mode S-Only All-Call at -21 dBm and the slave test set generating an ATCRBS Mode A interrogation at MTL +3 dB.

Step 7 Recovery (§2.2.7.2.4)

Connect the equipment as shown in Figure 2-32.

Step 7A Recovery from a Mode S interrogation which has not been accepted (§2.2.7.2.4) followed by an ATCRBS Mode-A

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address).

Set the Slave Test Set to generate an ATCRBS Mode-A interrogation having a signal level of ”MTL” + 3 dB.

Measure the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency.

Verify that the delay time is less than or equal to 45 microseconds after the Sync Phase Reversal (SPR) of the Mode-S surveillance interrogation.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the transponder does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Note: *Undesired replies are those containing any wrong or misleading information.*

Repeat the procedure given in preceding paragraphs with the Master Test Set using Mode-S interrogations that are accepted but do NOT require a reply (e.g., All-Call or Broadcast interrogations).

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7B Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by ATCRBS Mode-C

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate an ATCRBS Mode-C interrogation having a signal level of ”MTL” +3 dB.

Verify that the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency is less than or equal to 45 microseconds.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the UUT starts to reply to the Slave Interrogations prior to reaching a delay of 45 microseconds. Verify that the UUT does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7C Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by Mode S-Only All-Call

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate a Mode S-Only All-Call interrogation having a signal level of ”MTL” +3 dB.

Verify that the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency is less than or equal to 45 microseconds.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the UUT starts to reply to the Slave Interrogations prior to reaching a delay of 45 microseconds. Verify that the UUT does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7D <u>Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by ATCRBS Mode A/Mode S All-Call</u>

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate an ATCRBS Mode A/Mode S All-Call interrogation having a signal level of ”MTL” + 3 dB.

Verify that the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency is less than or equal to 45 microseconds.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the UUT starts to reply to the Slave Interrogations prior to reaching a delay of 45 microseconds. Verify that the UUT does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7E <u>Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by ATCRBS Mode C/Mode S All-Call</u>

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate an ATCRBS Mode C/Mode S All-Call interrogation having a signal level of ”MTL” + 3 dB.

Verify that the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency is less than or equal to 45 microseconds.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the UUT starts to reply to the Slave Interrogations prior to reaching a delay of 45 microseconds. Verify that the UUT does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step7F Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by ATCRBS Mode A-Only All-Call

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate an ATCRBS Mode A-Only All-Call interrogation having a signal level of ”MTL” + 3 dB.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it is greater than 45 microseconds.

Verify that the transponder does NOT reply to the Slave Interrogations.

Verify that the transponder does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7G Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by ATCRBS Mode C-Only All-Call

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate an ATCRBS Mode C-Only All-Call interrogation having a signal level of ”MTL” + 3 dB.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it is greater than 45 microseconds.

Verify that the transponder does NOT reply to the Slave Interrogations.

Verify that the transponder does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7H Recovery from a Mode-S interrogation which has not been accepted (§2.2.7.2.4) followed by Directed Mode-S

Set the Master Test Set to generate a standard (i.e., -60 dBm) Mode-S Surveillance interrogation with an incorrect address (i.e., an address different from that of the UUT Mode-S Discrete Address). Set the Slave Test Set to generate a Directed Mode S (i.e., an address equivalent to the UUT Mode-S Discrete Address) interrogation having a signal level of ”MTL” + 3 dB.

Verify that the delay of the Slave Test Set signal from the Mode-S Sync Phase Reversal (SPR) required to produce 90% reply efficiency is less than or equal to 45 microseconds.

Decrease the delay of the Slave Test Set signal such that the start of the Slave Interrogation is coincident with the end of the Master Interrogation. Then increase the delay of the Slave Interrogation such that it approaches 45 microseconds.

Verify that the UUT starts to reply to the Slave Interrogations prior to reaching a delay of 45 microseconds. Verify that the UUT does not generate any undesired replies that can be detected by a properly operating Mode-S 1090 MHz PAM receiver.

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

Step 7I Recovery from a suppression pair or unaccepted Mode A/C/S All-Call or Mode A/C-only All Call (§2.2.7.2.2 and §2.2.7.2.4)

Set the Master Test Set to generate a P_1-P_2 pulse pair at the Mode A/C standard interrogation rate and a power level equal to -35 dBm. Set the Slave Test Set to generate a Mode S-Only All-Call interrogation having a signal level of ”MTL” +3 dB. Measure the delay of the Slave Test Set signal from the P_2 pulse required to produce 90% reply efficiency. Verify that the delay time is less than or equal to 15 microseconds after the P_2 pulse.

Repeat the procedure with the Master Test Set using Mode A/C/S All-Call interrogations **while locking-out** the transponder to these All Call interrogations in place of suppression pair. Verify that the delay time is less than or equal to 15 microseconds after the P_4 pulse.

Repeat the procedure in the preceding paragraph with the Master Test Set using Mode A/C-only All-Call interrogations in place of a suppression pair.

2.4.2.7 Response to Interference (§2.2.8)

Equipment Required:

Mode S Transponder Test Set.
ATC Test Set (TIC T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
3 Port Power Divider (Weinschel 1506, or equivalent).

Measurement Procedure:

With the equipment connected as shown in Figure 2-32, interrogate the transponder with the standard Mode S-Only All-Call interrogation at a signal level of -50 dBm and follow Steps l through 4 below.

Step 1 Low Level Asynchronous Interference (§2.2.8.1)

Insert a 0.8-microsecond wide pulse [defined in §2.4.1.i (ll)] with amplitude 12 dB below P_1 of the standard Mode S-Only All Call at a repetition rate of 10000 Hz. Measure reply ratio. Repeat the test for all signal levels between -65 and -21 dBm in 5-dB increments.

Note: *Take care to avoid synchronization of the 10000 Hz rate with the Mode S standard rate.*

Step 2 Standard Interference Pulse (§2.2.8.2) and Mode S SLS (§2.2.5.2)

Insert the interfering pulse (duration: 0.8 microsecond, level 6 dB below P_6) at a position l.8 microseconds after the leading edge of P_6 of a standard Mode S-Only All-Call.

Observe the reply ratio while slowly moving the interfering pulse from its initial position to the end of P_6. Repeat the test for all signal levels between -68 and -21 dBm in 5-dB increments.

Repeat the test with an interference pulse level 3 dB below the P_6 level.

Insert the interfering pulse (now acting as P_5) 0.85 microseconds after the leading edge of P_6 and use a level 3 dB above the level of P_6. Use signal levels between MTL +3 dB and -21 dBm in 5-dB increments. Reply ratio in all cases should be 10 percent or less (§2.2.5.2.a).

Reduce level of P_5 to a value 12 dB below the level of P_6 and repeat the test at signal levels from MTL +3 dB to -21 dBm in 5-dB increments. Reply ratio should be 99 percent or more (§2.2.5.2.b).

Step 3 Pulse Pair Interference (§2.2.8.3)

Insert a 0.8 microsecond pulse pair spaced 2.0 microseconds apart [§2.4.1.i(11)] with amplitude 9 dB below P_1 of the standard Mode S-Only All-Call, at a position such that the leading edge of the pulse pair occurs 0.25 microseconds after the leading edge of P_1.

Record the reply ratio while moving the interfering pulse pair in 0.25 microsecond steps from its initial position to a position 0.25 microseconds after the falling edge of P_6. Determine the average reply efficiency from the recorded values.

Repeat the test for all input levels between –68 dBm and –21 dBm in 5-dB increments.

Step 4 DME and JTIDS Interference Tests (§2.2.8.4)

Insert 3.5-microsecond wide pulse pairs spaced 12 microseconds apart with amplitudes of -30 dBm at a rate of 3600 randomly spaced pulse pairs per second. Observe the reply ratio as the frequency of the interfering signal is varied over the ranges of 962 to 1020 MHz and 1041 to 1213 MHz.

Repeat the test using 3.5-microsecond wide pulse pairs spaced 30 microseconds apart.

Repeat the test using 6.4-microsecond wide pulse pairs at a random rate of 2000 pulses per second, with an amplitude of -80 dBm and a frequency of 1030 MHz.

Step 5 Standard Interference Pulse Positioned at Mode A or Mode C Spacing before P_2 of a P_1-P_2 Suppression Pair (§2.2.8.2 and §2.2.8.5)

Note: *The purpose of this test is to demonstrate that when the interference pulse combines with the P_2 pulse of the P_1-P_2 suppression pair in a manner that results in a simultaneous detection of a Mode A/C interrogation and a Suppression Pair, that the transponder goes into suppression and does not reply.*

(1) Mode A

Insert standard interfering pulse 8 µs before, and at the same signal level as, the P_2 pulse of a standard P_1-P_2 Suppression pair.

Verify that the transponder does not reply.

(2) Mode C

Insert standard interfering pulse 21 µs before, and at the same signal level as, the P_2 pulse of a standard P_1-P_2 Suppression pair.

Verify that the transponder does not reply.

Step 6 Standard Interference Pulse Positioned at Mode A or Mode C Spacing before P_1 of a Mode S Interrogation (§2.2.6.1.2.b)

Note: *The purpose of this test is to demonstrate that when the interference pulse combines with the P_1 pulse of the P_1-P_2 pair of a Mode S interrogation, that the transponder does not reply with an ATCRBS reply.*

(1) Mode A

Insert standard interfering pulse 8 µs before, and at the same signal level as, the P1 pulse of a standard Mode S Only All-Call interrogation.

Verify that the transponder does not reply with an ATCRBS reply.

(2) Mode C

Insert standard interfering pulse 21 µs before, and at the same signal level as, the P_1 pulse of a standard Mode S Only All-Call interrogation.

Verify that the transponder does not reply with an ATCRBS reply.

Note: *In both case (1) and (2), transponders that are designed to continue processing of the Mode-S interrogation after discarding the Mode A/C Only All-Call may reply to the Mode-S interrogation.*

Step 7 Standard Interference Pulse Positioned at Mode A or Mode C Spacing before P_2 of a Mode S Interrogation (§2.2.5.1.d.(5))

Note: *The purpose of this test is to demonstrate that when the interference pulse combines with the P_2 pulse of the P_1-P_2 pair of a Mode S interrogation, that the transponder suppresses replies to ATCRBS interrogations but replies to the Mode S interrogations.*

(1) Mode A

Insert standard interfering pulse 8 µs before, and at the same signal level as, the P_2 pulse of a standard Mode S Only All-Call interrogation.

Verify that the transponder replies to the Mode S Only All-Call interrogation.

(2) Mode C

Insert standard interfering pulse 21 µs before, and at the same signal level as, the P_2 pulse of a standard Mode S Only All-Call interrogation.

Verify that the transponder replies to the Mode S Only All-Call interrogation.

Step 8 Standard Interference Pulse Positioned at Mode C Spacing before P_4 of a Mode A Only All-Call Interrogation (§2.2.18.2.2.k)

Note: *The purpose of this test is to demonstrate that when the interference pulse combines with the P_4 pulse of the P_1-P_3-P_4 Mode A Only All-Call interrogation, that the transponder does not reply.*

Insert standard interfering pulse 21 µs before, and at the same signal level as, the P_4 pulse of a Mode A Only All-Call interrogation.

Verify that the transponder does not reply.

Step 9 Response in the Presence of CW Interference (§2.2.8.6)

Interrogate the transponder with standard ATCRBS Mode A or Mode C interrogations having a signal level of –50 dBm.

Insert non-coherent CW interference at a frequency of 1030 ±0.2 MHz and at signal levels of -70 dBm.

Verify that the transponder continues to reply to at least 90 percent of all interrogations.

Repeat the procedure using Mode S UF = 4, 5, 20 or 21 interrogations.

Step 10 Compatibility with TCAS ATCRBS Surveillance (§2.2.8.7)

a. Interrogate the transponder with a Mode A interrogation, having P_1 at MTL. Inject an S_1 pulse ahead of a P_1 pulse at MTL -6 dB. Verify at least 90% reply rate efficiency.

b. Continue the interrogation as in part "a" above. Set the level of S_1 to MTL -3 dB and verify at least 70% reply rate efficiency.

c. Continue the interrogation as in part "a" above. Set the level of S_1 to MTL and verify reply rate efficiency of not more than 10%.

2.4.2.8 Undesired Replies (§2.2.9)

Equipment Required:

ATC Test Set (T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
Frequency Counter (HP 5381A, or equivalent).

Measurement Procedure:

Step 1 Non-Interference Environment

Connect the equipment as shown in Figure 2-37. Set the ATC test set to ZERO interrogation rate. Set the oscilloscope to a total sweep time of 100 microseconds and the internal trigger to allow one sweep for each reply group transmitted by the transponder. Count the number of replies for a minimum of one minute. The squitter generation function may be disabled for this test.

Step 2 Random Trigger Rate (§2.2.9.1.b and §2.2.9.2.b)

Repeat the procedure provided in Step 1 while injecting non-coherent CW interference at a frequency of 1030 ±0.2 MHz, at a signal level of –60 dBm.

Count the number of replies for a minimum of one minute and verify that the reply rate does not exceed the limits specified in §2.2.9.1.b and §2.2.9.2.b.

2.4.2.9 Self-Test and Monitors (§2.2.10)

Equipment Required:

ATC Test Set (TIC T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).
RF Attenuator (HP 394A, or equivalent).
ATC Transponder (Similar to unit under test - transmitter disabled).
Frequency Counter (HP 5381A, or equivalent).

Measurement Procedure:

Step l Self-Test Interrogation/Reply Rate (§2.2.10.1 a and c)

Connect the equipment as shown in Figure 2-37. Set the ATC test set to ZERO PRF, and the oscilloscope to a total sweep time of 50 microseconds, using internal trigger. Activate the self-test function (if provided) of the transponder under test and determine the reply rate to the self-test interrogation.

The squitter generation function may be disabled for this test.

Step 2 Self-Test Interrogation Level (§2.2.10.1.b)

Arrange coax connections as shown in Figure 2-38, position A. Activate the self-test function of the transponder and adjust the RF attenuator until the other transponder just triggers, as indicated by the presence of suppression pulses.

Without changing the RF attenuator setting, change the coax connections to position B. Set the ATC test set to the interrogation rate determined in Step 1 and interrogate in Mode A. Adjust the RF level of the ATC test set until transponder number two just triggers. Record the ATC test output level.

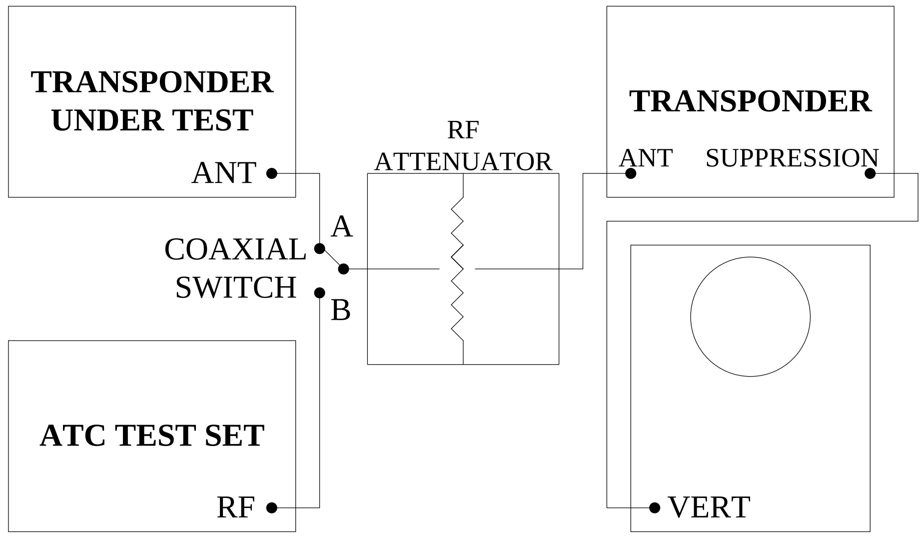


Figure 2-38: Test Equipment Connection

2.4.2.9.1 Squitter Monitor (§2.2.10.2)

A specific test procedure for this function is not described in this subsection. Such a test requires that the manufacturer artificially disable the squitter generation function. The detailed procedure for proving this capability must be left to the discretion of the manufacturer.

2.4.2.9.2 Failure Annunciation (§2.2.10.4)

As a minimum, the manufacturer must demonstrate that failures detected by the self-test or monitors are properly detected and that those failures cause the “valid” output to assume an invalid state.

2.4.2.10 Interference Suppression Pulse Response (§2.2.11)

Equipment Required:

ATC Test Set (TIC T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Connect the equipment as shown in Figure 2-39. Interrogate on Mode A at 150 interrogations per second and set the signal level to -21 dBm. Apply the suppression pulse for which the equipment is designed. Starting with a delay of more than 15 microseconds, adjust for minimum delay between the trailing edge of the suppression pulse and the leading edge of the interrogation pulse pair which provides 90 percent reply efficiency. Determine value of minimum delay.

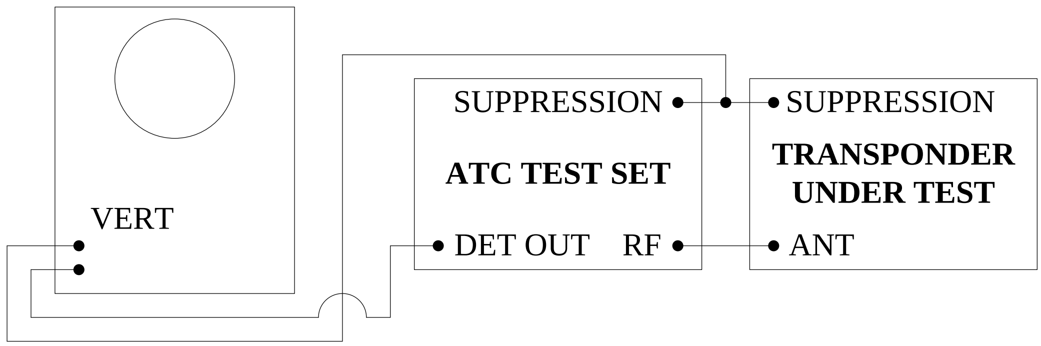


Figure 2-39: Test Equipment Connection

2.4.2.11 Diversity Operation (§2.2.12 and §2.2.22.d)

Equipment Required:

Two means of generating identical ATCRBS and Mode S interrogations that can be delayed from each other from 125 to 375 nanoseconds. These two generators must also have independent control of power level.

Means of determining the antenna terminal that generates the reply.

Means of determining the reply power level on both antennas simultaneously.

Means of determining reply delay for each channel and between channels.

Measurement Procedure:

Note: *Because the specifications for diversity operations are symmetrical in all respects, channels are arbitrarily designated A and B.*

Step 1 Single Channel Test (§2.2.12.3 and §2.2.12.4)

When measuring channel A and B parameters take care that any cables used for measurements are of equal length and equal loss. Interrogate channel A only, while monitoring channel A and B. At signal level MTL +3 dB use the following types of interrogations and record the listed observations:

ATCRBS Mode A.
ATCRBS Mode C.
ATCRBS Mode A/Mode S All-Call.
ATCRBS Mode C-only All-Call.
Mode S formats UF=4, 11, and if so equipped, 21.

For signal levels of -50 dBm and -21 dBm use an ATCRBS Mode C and a Mode S format of UF=4 types of interrogations and record the listed observations.

Observe:

Correct reply ratio.
Correct reply channel.
Power level of replies from channel A (§2.2.12.3).
Power level of replies from channel B (§2.2.12.3).

Record: Reply delay for each interrogation signal type and for the signal levels as specified.

Repeat the above test reversing channels.
Compare records of reply delays for conformance with §2.2.12.4.

Step 2 Selection Test (§2.2.12.1)

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.04 microseconds apart where channel A is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL and a power level on channel B of MTL +3 dB.

Observe that 90 percent of the replies are on channel B.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +3 dB and a power level on channel B of MTL.

Observe that 90 percent of the replies are on channel A.

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.04 microseconds apart where channel B is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL and a power level on channel B of MTL +3 dB.

Observe that 90 percent of the replies are on channel B.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +3 dB and a power level on channel B of MTL.

Observe that 90 percent of the replies are on channel A.

Step 3 Delay-Selection Test (§2.2.12.2)

Synchronize the interrogations to channels A and B so that they are 0.375 +.040/-0.00 microseconds apart where channel A is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of MTL +3 and a power level on channel B of -50 dBm.

Observe that 90 percent of the replies are on channel A.

Synchronize the interrogations to channels A and B so that they are 0.375 +0.040/-0.00 microseconds apart where channel B is first.

Use an ATCRBS Mode C and a Mode S UF=4 to interrogate at a power level on channel A of -50 dBm and a power level on channel B of MTL +3.

Observe that 90 percent of the replies are on channel B.

Step 4 Squitter Antenna Selection (§2.2.12.5)

Activate the transponder and determine that squitter transmissions occur alternately from the two antennas at the prescribed rate.

2.4.2.12 Data Handling and Interfaces (§2.2.13)

The procedures outlined in this paragraph are intended only to test "data in" and "data out" requirements of the transponder. They do not constitute tests of the transponder's digital logic and protocols. Some tests correspond to requirements of optional features, and therefore are not applicable to all transponders.

2.4.2.12.1 Fixed Direct Data (§2.2.13.1.1)

Equipment Required:

Mode S Transponder Test Set (§2.4.1.i).

Measurement Procedure:

With the transponder RF port connected to the RF port of the Mode S transponder test set, perform the following test sequences.

Step 1 Mode S All-Call Addresses [§2.2.13.1.1.a (l)]

Interrogate the transponder with a Mode S-Only All-Call interrogation with PR, IC and CL Fields set to 0. Verify that the AA field of the transponder reply reflects the address which has been set into the transponder. Twenty-four different addresses consisting of 23 ZEROs and a single ONE **shall** be tested.

Step 2 Mode S Discrete Address [§2.2.13.1.1.a (2)]

Interrogate the transponder with a standard Mode S surveillance-altitude interrogation (UF=4) with the PC, RR, DI and SD fields set to 0 and an address consisting of ONE followed by 23 ZEROs. Verify that the transponder replies with appropriate bits set in the AP field when a like address is set into the transponder, and will not respond when each of the other combination of 23 ZEROs and a single ONE are entered as addresses.

Step 3 Maximum Airspeed (§2.2.13.1.1.b)

Interrogate the transponder with a short special surveillance interrogation (UF=0) with the AQ field set to 1. Verify that the RI field of the transponder reply corresponds to the airspeed code set into the transponder as each of the seven possible airspeed codes is used.

Step 4 Aircraft Identification Data (§2.2.13.1.1.c)

Perform the test procedure provided in §2.6.6.3.a and §2.6.6.3.b.

Step 5 Invalid AA

a. Put the transponder in the Power Off Condition and set the AA to ALL ZEROs. Turn on the transponder and verify that a transponder error condition is set and a failure is declared.

   Repeat test "a" with the AA set to ALL ONEs.

Note: *In both cases, the transponder will normally either go into Standby State, revert to a pure Mode A/C transponder, or return to the Power Off Condition.*

b. Put the transponder in the Power On Condition with an AA set to ONE (1) for the first bit and ZEROs for all other bits. Verify that the transponder replies to all properly addressed interrogations.

Without putting the transponder in Power Off Condition, change the AA to ALL ZEROs. Verify that the transponder generates a diagnostic error message for maintenance, and that it keeps operating using the initial AA read during the power-on initialization process (first bit set to ONE (1) and all other bits set to ZEROs).

c. Repeat "b" with the remaining twenty-three different transponder addresses each consisting of 23 ZEROs (0) and a single ONE (1).

d. Repeat tests "b" and "c" with the AA set to ALL ONEs, instead of ALL ZEROs.

2.4.2.12.2 Variable Direct Data (§2.2.13.1.2)

Equipment Required:

Mode S Transponder Test Set.
ATC Test Set (T-50-3A/4A, or equivalent).
Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Step 1 Pressure Altitude (ATCRBS) [§2.2.13.1.2.a (l)]

Connect the equipment as shown in Figure 2-31. Interrogate the transponder with a standard ATCRBS Mode C interrogation. With the ALT switch on, set altitude code inputs to the transponder, which should result in setting each of the altitude bits in the reply one at a time. Verify proper positioning of these bits in the reply. Verify that only the framing pulses are present in the reply when the ALT switch is set to "off."

Step 2 4096 Identification Code (ATCRBS) (§2.2.13.1.2.b)

With equipment connected as in Step l, interrogate the transponder with a standard ATCRBS Mode A interrogation. Set identification codes which should result in the setting of each of the identification reply bits one at a time. Verify proper positioning of these bits in the reply.

Step 3 Pressure Altitude (Mode S) [§2.2.13.1.2.a (2)]

a. Connect the transponder RF port to the transponder test set.

b. Interrogate the transponder with a standard surveillance-altitude interrogation (UF=4) with the PC, RR, DI and SD fields set to ZERO and the address the same as that provided to the transponder.

c. With the ALT switch ON, provide altitude code inputs from an altitude source in feet quantized to greater than 25 feet to the transponder which should result in setting each of the AC field bits of the reply, one at a time.

d. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ZERO (0) and the M bit set to ZERO (0).

e. With the ALT switch ON, provide altitude code inputs from an altitude source in feet quantized to 25 feet, or less, to the transponder, and verify that the altitude report is correct as a minimum when the input indicates pressure altitudes of 17050 and 34125 feet.

f. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ONE (1) and the M bit set to ZERO (0).

g. With the ALT switch ON, provide altitude code inputs from an altitude source quantized to 25 feet, or less, to the transponder. Verify that the altitude report is correct when the input indicates pressure altitudes of between 50188 feet and 126700 feet, which should result in setting each of the AC field bits of the reply.

h. Verify that the correct bits are transmitted in the AC field of the reply with the Q bit set to ZERO (0) to indicate a report to 100 feet quantization and the M bit set to ZERO (0).

i. Repeat Step 3 (1) to (8) with the input indicating metric input, if available, and verify that the M bit is set to ONE (1) in the AC field of all replies.

Verify that the AC field is ALL ZEROs when the ALT switch is set to "OFF."

Set the input altitude data to invalid and verify that the AC field is ALL ZEROs.

Step 4 Identification Code (Mode S) (§2.2.13.1.2.b)

With the equipment connected as in Step 3, interrogate the transponder with a standard surveillance-identity interrogation (UF=5) with PC, RR, DI and SD fields set to ZERO (0) and the address the same as that provided to the transponder. Using the identity codes specified in Step 2, verify that the proper bit patterns exist in the ID field of the reply.

Step 5 Flight Status and Vertical Status (§2.2.13.1.2.c)

Interrogate with UF=0 and UF=16 and verify that the VS field is a ONE (1) when the "on-the-ground port" of the transponder is set to the on-the-ground condition. Also, verify that the VS field is a ZERO (0) otherwise.

Interrogate with formats UF=4, 5, 20, 21 and verify that the transponder follows the protocol of §2.2.14.4.15, and Figure 2-17.

Step 6 Aircraft Identification Data (§2.2.13.1.2.e)

a. Perform the test procedure provided in §2.6.6.1.a.(1).

b. Perform the test procedure provided in §2.6.6.1.b with the exception that the Test Timer need not be implemented to monitor the "B" timer.

c. Perform the test procedure provided in §2.6.6.5.a.(1).

d. Perform the test procedure provided in §2.6.6.5.b.

2.4.2.12.3 Standard Transaction Interfaces (§2.2.13.3)

Equipment Required:

Mode S Transponder Test Set.
Means of Inserting and Extracting Data at Transponder Interface Ports.
Means of Timing Transactions.

Measurement Procedures:

With the transponder RF port connected to the RF port of the Mode S Transponder Test Set, perform the following test sequences.

Step l Uplink Interface Information Content (§2.2.13.3.1 a and e)

Interrogate the transponder with valid Mode S interrogations of all uplink formats which the transponder is designed to accept, including broadcast interrogations. Verify that all fields (possibly excluding AP) of the interrogations are passed correctly through the transponder and except for UF=0, 11, 16, and 24 (when it is a request for a downlink ELM), appear at the uplink interface. Make additional valid interrogations with the uplink formats (excluding UF=11 and UF=24) and field content randomly chosen. Verify proper output of the uplink interface. Verify that broadcast interrogations are identified as such, either by AP content or by a special purpose code.

Step 2 Uplink Interface, "No-Storage Design" (§2.2.13.3.1.b)

Interrogate the transponder with valid Mode S interrogations of all uplink formats which the transponder is designed to accept. Verify that all data appear correctly at the uplink interface prior to the start of the transponder reply.

Step 3 Uplink Interface, "Storage Design" Acceptance Rate (§2.2.13.3.1.c)

Interrogate the transponder with valid Mode S interrogations (both short and long) at the rates and time periods specified in §2.2.3.4.2. Verify that all data appear correctly at the uplink interface.

Step 4 Uplink Interface, Non-acceptance (§2.2.13.3.1.d)

Interrogate the transponder with valid long Mode S interrogations at a rate exceeding the one specified in §2.2.3.4.2 for the longest time period. Verify that the transponder does not accept interrogations after the rate for which the transponder is designed has been exceeded. Also, verify that all data correctly appear at the uplink interface for all accepted interrogations.

Note: *With the uplink interface disconnected, the transponder may, or may not, reply to valid long Mode S interrogations.*

Step 5 Downlink Interface, Information Content (§2.2.13.3.2.a)

Insert an all ONEs input. Interrogate the transponder with all uplink formats that it is designed to accept (one interrogation of each format, RR=16 for long interrogations). Verify that all bits in the transponder replies, not set by transponder protocol requirements, are ONE. Verify that all fields in the replies, set by transponder protocol, have the correct value.

Repeat this procedure with MB field data context 55 5555 5555 5555.

Step 6 Downlink Interface, "No-Storage Design" (§2.2.13.3.2.b)

Insert an all ONEs input. Interrogate the transponder with a standard Comm-A, altitude interrogation. Verify that data are inserted into the transponder at the proper time, and that the transponder reply contains the proper data.

Step 7 Downlink Interface, "Storage Design" Buffer Rate, Buffer Function (§2.2.13.3.2.c)

Set up a sequence of Comm-B replies with the value of the last 48 bits of MB of each reply set to the number of the reply in the sequence (e.g., MB=1 for first reply). Interrogate the transponder with a standard Comm-A, altitude interrogation at the rates specified for long interrogations in §2.2.3.4. Verify that the replies include the proper data in the MB field. Repeat with RR equal to all valid codes from 16 through 18.

Step 8 Downlink Interface, Unavailable Data (§2.2.13.3.2.e)

Disconnect all inputs from the transponder's downlink interface port. Interrogate the transponder with a standard Comm-A, altitude interrogation containing RR=16. Verify that the reply contains ALL ZEROs in the MB field. Repeat with all RR codes from 17 through 31, noting that:

- For RR code 17, bits of the MB field of the reply excluding bits 1-8, 24, 26-36 are set to ZEROs (bits 1-8, 24, 26- 36 are or may eventually be set by the transponder itself when no interface is available).
- For RR code 18, the reply contains all ZEROs excluding bits 1 – 8, in the MB field if the aircraft identification consists of variable direct data, or the tail number if the aircraft identification consists of fixed direct data.
- For RR code 19, bits 9-56 of the MB field of the reply are set to ZEROs.
- For RR codes 20 through 31, verify that the reply contains ALL ZEROs in the MB field.

2.4.2.12.4 ELM Service Interfaces (§2.2.20.1.4 and §2.2.20.1.2)

Equipment Required:

Mode S Transponder Test Set.
Transponder ELM Data Link Device.

Measurement Procedure:

Connect the transponder RF port to the RF port of the Mode S transponder test set. Connect the Mode S transponder test set of the ELM data link device to the ELM interface port of the transponder and perform the following sequences.

Step 1 ELM Uplink Interface, Data Rate (§2.2.20.1.4)

Interrogate the transponder with four 16-segment uplink ELMs (each segment having unique coding, interrogations spaced 50 microseconds apart, and a new 16-segment ELM starting 5 milliseconds after the previous ELM). After 4 seconds for transponders equipped for standard ELM operation or after 1 second for transponders equipped for enhanced uplink ELM operation, interrogate the transponder with another set of four 16-segment ELMs. Verify that the correct data appears at the ELM interface no later than one second after completion of the corresponding uplink ELM for both interrogation sequences. Verify that the interface reports an interrogator identity code of ZERO.

Step 2 ELM Uplink Interface, Interrogator Identification (§2.2.20.1.2)

Repeat the procedures of Step 1 using the multisite protocol. Use different Interrogator Identifier codes and verify that they are correctly reported at the interface.

Step 3 ELM Downlink Interface, Data Rate (§2.2.20.2.4 and §2.2.3.5)

Set up a downlink ELM which conforms to the maximum capability of the transponder (each segment with unique coding) on the Mode S transponder test set or ELM data link device. Interrogate the transponder with a Comm-C (UF=24) with RC=3 and SRS= "ALL ONEs." Verify that all segments are properly transmitted 136 ±1 microseconds apart.

2.4.2.12.5 Interface Integrity Testing (§2.2.13.2.2)

Compliance with this requirement **shall** be demonstrated either by direct test in a simulated operational environment or by analysis based on the known characteristics of proven interface techniques.

2.4.2.12.6 Comm-B Downlink Interface, Message Cancellation (§2.2.20.2.2)

Step 1 Cancellation Before Transmission

Insert a Comm-B message into the downlink interface for transmission. Interrogate the transponder with UF=4, 5, 20 and 21 and verify that the DR code in its replies is set to ONE (1). Cancel the message via the interface, interrogate again and verify that the DR code is now not ONE (1).

Step 2 Cancellation After Transmission

Insert message as in Step 1, interrogate and extract message as in §2.2.19.1.12.4, using RR=16. Cancel message via the interface, interrogate again to verify that that DR is now not ONE (1).

Step 3 Cancellation in Multisite Environment

Prepare two messages of differing content, m1 and m2, for insertion into the interface. Insert m1 as in Step 1 and extract using the multisite protocol (RR=16, DI=1, IIS>0, MBS=1). Cancel m1 via the interface and verify that DR is not 1 and that the UM field does not show a Comm-B reservation. After that verification, and within less than 15 seconds, insert m2 into the interface and extract using the multisite protocol with different IIS. Verify that the second message has been extracted and close out the transaction using DI=1, IIS as for m2, MBS=2 (see §2.2.19.2.3.3). Verify that DR is not 1 and that the UM field does not show a Comm-B reservation.

Note: *This two-message sequence is needed to verify that a complete cancellation has been achieved by way of the interface.*

Step 4 Cancellation Within a Queue

If the interface is designed to store more than one message in the transponder, where one message is ready to be transmitted and other messages are queued for subsequent transmission, the following test must be performed.

Insert the maximum number of messages into the transponder and cancel one of the messages that is not scheduled for immediate transmission. Extract all messages and verify that the cancelled message does not appear. Repeat for each possible message location in the queue.

2.4.2.12.7 Downlink ELM Interface, Message Cancellation (§2.2.20.2.2)

Step 1 Cancellation Before Transmission

Insert an ELM message occupying as many segments as the transponder will permit into the downlink interface for transmission. Interrogate the transponder with UF=4, 5, 20 and 21 and verify that the DR code in its replies is larger than 16 and reflects the number of inserted segments correctly. Cancel the message via the interface, interrogate again, and verify that the DR code is now not larger than 16.

Step 2 Cancellation After Transmission

Insert message as in Step 1, interrogate and extract message as in §2.2.20.2.1.1.2, using RC=3. Cancel message via the interface, interrogate again to verify that DR is now not larger than 16.

2.4.2.13 Acquisition Squitter (§2.2.12.5.1 and §2.2.18.2.6)

a. Establish the appropriate conditions where the transponder is in the airborne state and provides Acquisition Squitter transmissions.

b. Verify that the transponder provides Acquisition Squitter transmissions that:

   1. Are transmitted at average intervals of 0.8 to 1.2 seconds,
   2. Are alternated between the top and bottom antenna for diversity transponders, and
   3. Contain the appropriate message content.

c. Establish the appropriate conditions where the transponder is in the on-ground state and provides Acquisition Squitter transmission.

d. Verify that the transponder provides Acquisition Squitter transmissions that:

   1. Are transmitted at average intervals of 0.8 to 1.2 seconds,
   2. Are transmitted from the top antenna for diversity transponders, and
   3. Contain the appropriate message content.

2.4.2.14 Extended Squitters (§2.2.12.5.2 and §2.2.23)

Step 1 Airborne Position Message Validation (§2.2.12.5.2, §2.2.23.1.3.b)

(1) Establish appropriate conditions where the transponder declares the Airborne State.

(2) Provide the transponder with appropriate latitude, longitude and altitude data via an appropriate interface.

(3) Verify that the transponder provides ADS-B Airborne Position Message Extended Squitter transmissions that:

- are transmitted at average intervals of 0.40 to 0.60 seconds,
- are alternated between the top and bottom antenna for diversity transponder, and
- contain the appropriate information in the “ME” field.

Step 2 Airborne Velocity Message Validation (§2.2.12.5.2, §2.2.23.1.3.e)

(1) Provide the transponder with appropriate velocity data via an appropriate interface.

(2) Verify that the transponder provides ADS-B Airborne Velocity Message Extended Squitter transmissions that:

- are transmitted at average intervals of 0.40 to 0.60 seconds,
- are alternated between the top and bottom antenna for diversity transponders, and
- contain the appropriate information in the “ME” field.

Step 3 Aircraft Identification Message Validation (§2.2.12.5.2, §2.2.23.1.3.d)

(1) Provide the transponder with appropriate aircraft identification data via an appropriate interface.

(2) Verify that the transponder provides ADS-B Aircraft Identification Message Extended Squitter transmissions that:

- are transmitted at average intervals of 4.8 to 5.2 seconds,
- are alternated between the top and bottom antenna for diversity transponders, and
- contain the appropriate information in the “ME” field.

Step 4 Surface Position Message Validation (§2.2.12.5.2, §2.2.23.1.3.c)

(1) Establish appropriate conditions where the transponder declares the On-Ground State.

(2) Provide the transponder with appropriate latitude and longitude data via an appropriate interface.

(3) Verify that the transponder provides ADS-B Surface Position Message Extended Squitter transmissions that:

- are transmitted at average intervals of 4.8 to 5.2 seconds,
- are transmitted on the top antenna only for diversity transponders, and
- contain the appropriate information in the “ME” field.

2.5 Test Procedures for the Surveillance and Communications Protocols

2.5.1 Introduction

This subsection includes tests to verify the transponder's processing functions. (The tests described in Subsection §2.4 verify transponder performance as a receiver and transmitter of signals.) The nature of these processing tests is such that some means of automatically controlling, sequencing and evaluating the tests is necessary if the tests are to be practical. It is assumed that an automatic capability is available for executing these tests.

The only exception is a technique for manual testing of Mode S parity, which is included as a simple procedure for verifying the proper implementation of the parity codes.

Transponder States:

Upon receipt of an interrogation, the action of a Mode S transponder is dependent upon the interrogation type and format, and the "state" of the transponder at the time of receipt. The address of the interrogation must be correct, the format must be one the transponder is equipped to receive, and the reply format requested must be within the capability of the transponder. If all of the above criteria are met, and if the transponder is not locked out to the interrogator identity, the interrogation will be accepted. The content of the reply will depend not only on the content of the interrogation but also on control inputs to the transponder, such as Alert and SPI, and on data existing at the transponder interfaces such as the altitude code and waiting messages.

The overall state of a Level 1 transponder is determined by the status of 82 timers: Suppression, Lockout, Alert, SPI, and 78 selective lockout timers.

Data link transponders have additional possible states defined by data link reservation timers and the condition of link protocol status registers.

A Level 1 transponder could receive $2^{56} \approx 7x10^{16}$ different interrogation patterns, of which about 33 million must be accepted because they are of the correct address and format. Of these, about 200 require that a correct reply, as specified in Subsection §2.2 of this document, be returned. The corresponding numbers for data link transponders are proportionally larger.

Certain interrogation patterns are illogical and should never be transmitted by an interrogator. It is also physically impossible for certain combinations of timer and register conditions to occur simultaneously in a correctly functioning transponder. However, if any illogical interrogation pattern is inadvertently transmitted, the transponder must not respond inappropriately or transition to an improper state. Thus, tests are included to subject the transponder to specific illogical interrogation patterns to verify that it reacts as specified in Subsection §2.2.

Logic Tests:

Many of the specifications of Subsection §2.2 involve "sufficient condition" logic. That is, taken in the context of the entire document, the statement “On receipt of PC=1 the transponder **shall** be locked out," means: "If and only if PC=1, the transponder **shall** be locked out." The tests then must verify that PC=1 causes the lockout state, and also that other signals (some of which may include other messages in the same location used for the PC field) do not cause this state.

Exhaustive tests would have to combine all possible interrogation patterns with all possible transponder states; verify that the transponder takes the specified action for specified combinations of interrogation patterns and transponder states; and verify that it takes no action for all other combinations.

The number of possible state-pattern combinations makes it impossible to perform exhaustive tests within a reasonable time period. A practical test procedure separates required tests into two categories: Positive tests and negative tests.

Positive tests verify that the transponder acts as required by the specifications in Subsection §2.2 and the accompanying flowcharts. For example, PC=1 received in the correct format must cause lockout for the specified time.

Negative tests verify that the transponder does not react to unspecified codes or patterns. For example PC=1 must not cause lockout.

The positive tests included are exhaustive in the sense that every action specified in Subsection §2.2 is tested. Negative tests have been chosen according to the seriousness of a possible malfunction. For example, negative tests of the lockout protocol are important because a malfunction can make the transponder invisible to a sensor. Thus, all PC codes are tested.

Tests for Data Flow:

Data flow must also be verified. However, totally exhaustive testing of data flow is not practical. Tests for data flow cannot be clearly classified as positive or negative. They are designed such that all connections between input and transponder action are verified. The procedures are intended to identify the most probable failure modes.

Accuracy of data transfer by the transponder in either direction is verified by these tests. That is, message patterns entering must be identical with message patterns leaving the transponder.

Scope of Tests:

The tests will verify that the functions required by the text in Subsection §2.2 are carried out regardless of the design approach.

2.5.2 Required Test Equipment

The test equipment described here is required for all procedures except Procedure #1.

2.5.2.1 Automatic Test Controller

The controller **shall** be capable of sequencing the test procedures and analyzing the content of the transponder's responses. Program instructions for the controller must be generated by the user according to the procedures of §2.5.4 and the instructions of §2.5.3.b.

2.5.2.2 Signal Generator

The signal generator **shall**:

a. Generate nominal (§2.1.11.3 and §2.1.11.4) waveforms for ATCRBS and Mode S interrogations.

b. Be capable of a continuous interrogation rate of 50/sec (Some tests for a TCAS-compatible transponder require 60/sec.).

c. Be capable of a peak interrogation rate of 2500/sec (§2.2.3.4.2).

d. Have a parity generator (§2.2.18.2.1.c and Figure 2-10).

e. Have means to accept control commands for:

    (l) The type of interrogations to be made (ATCRBS A, C; ATCRBS/Mode S All-Call; ATCRBS-Only All-Call; Mode S formats).

    (2) The value (ONE or ZERO) for each bit in a Mode S interrogation, excluding the bits in the AP field.

    (3) The value (ONE or ZERO) for each bit of the Mode S address.

    (4) The timing of the interrogation.

f. Generate interrogation signal levels of -60 and 0 dBm.

2.5.2.3 Reply Receiver

The reply receiver **shall**:

a. Accept all ATCRBS replies and pass on their content to the controller.

b. Accept all Mode S replies, carry out the decoding function for AP or PI (Figure 2-11), and pass on the reply content and the decoded address or the interrogator identity to the controller.

2.5.2.4 Interface Adapter

The interface adapter **shall** be able to transfer information content between all applicable interfaces and the controller in either direction.

Some tests require the use of equipment that simulates certain functions of a TCAS unit. The simulation equipment should enable the transponder to send and receive data on the TCAS/transponder interface using appropriate interface protocols and response times appropriate for an actual TCAS operating with the TCAS/transponder interface. The simulation equipment should allow specific bit configurations to be sent to the transponder and allow for information received from the transponder to be examined.

Note: *Interface designs are not standardized, and therefore can range from one universal interface to several separate interfaces for direct and indirect data. Interfaces for some functions (4096, SPI, etc.) may not be electrically accessible and would thus require manual setting.*

2.5.3 Selection and Use of the Test Procedures

a. Selection

Given the range of possible transponder designs and capabilities, the test procedures of §2.5.4 must be chosen to match the transponder. Test procedures are included for:

Transponder	Reference	Procedures
Minimum Data Link Transponder	§2.2.19.1	2 to 23&29, excluding 18A
Data Link ELM-C Transponder	§2.2.20.1.1	2 to 25&29, excluding 18A
Data Link ELM-C/D Transponder	§2.2.20.2.1	2 to 29, excluding 18A
Enhanced Data Link Transponder	§2.2.21	2 to 29, excluding 18
TCAS Compatible Transponder	§2.2.22	30 to 39

The Error Protection Test (Procedure #1) is used to verify the correct operation of the error protection circuitry of the test equipment and the transponder. Its initial application is required for AP and PI.

b. Use

The test procedures in §2.5.4 constitute a detailed set of program instructions for the test controller.

The procedures describe a set of interrogation sequences and replies that must be carried out to verify one specific operation, protocol or action of the transponder. The number of required transactions (interrogation-reply pairs) may vary depending on the transponder design (for example, for diversity transponders, all tests must be applied to both channels) and the details of the controller instructions. The number of verifications is fixed for each transponder design.

Since each procedure sequence tests only one specific transponder action, it is possible to combine transactions such that more than one transponder action is tested. For example, while interrogation-reply protocols are being verified, the content of the interrogations can also be checked to verify reply content.

It is not required that the described sequences follow consecutively. Transactions of one sequence may be used to bring the transponder into a state required for another sequence. Other tests may be executed while waiting for timer runout.

The transponder is required to reply to at least 99% of valid interrogations in the Mode S format and to at least 90% in the ATCRBS format. Reinterrogation capability must be provided for instances of non-reply. Given the large number of transactions carried out during these tests, a valid reason for rejection would be a reply failure rate, cumulatively recorded, that exceeds the specified rate.

2.5.4 Test Procedures

2.5.4.1 Procedure #1: Error Protection

2.5.4.1.1 Procedure #1: Error Protection, AP and PI Fields (§2.2.18.2.1.c)

The correct function of the two coding-parity processes in the transponder can be automatically verified by a hardware circuit in the test generator, designed according to Figure 2-11. The test set (signal generator/analyzer) carries out the correct encoding process. A transponder will recognize the correct address and will in turn correctly generate the AP and PI fields.

It is also possible to observe the function of the transponder's and test set's error protection circuits if the AP pattern resulting from known text and address is known. However, since the correct values of 24 bits must be verified from an oscilloscope presentation, the deciphering of the phase reversals in the uplink P_6 or the relative pulse positions in the downlink becomes laborious.

Patterns for the AP field exist that are easily distinguished in an oscilloscope presentation. Combinations of text (the bit stream before the AP or PI fields) and address exist for which AP and PI consist of ALL ZEROs or of another easily recognizable and verifiable pattern. They are presented here.

Equipment Required:

Test set capable of generating Mode S interrogations at a 0 dBm power level.

DPSK modulation detector. Use a simple diode detector for manual determination of the location of phase reversals when the Mode S signal test generator is using hard keying with amplitude drop.

Note: *Such a method is only possible for test purposes as some transmitters can generate the phase reversal using IQ modulator with little or no amplitude drop.*

Wide-band oscilloscope (HP1710B, or equivalent).

Verification of Transponder's Downlink Encoding Circuit for PI

At the transponder's address setting interface, set addresses shown in the following list, depending on the internal CA report:

If CA=0, set AA to 03 13 D4 hex.
If CA=4, set AA to 03 2B E2 hex.
If CA=5, set AA to FC DF EB hex.
If CA=6, set AA to 03 37 F9 hex.
If CA=7, set AA to FC C3 F0 hex.

Interrogate with the ATCRBS/Mode S All-Call and verify that in the reply PI is ALL ZEROs.

Note: *This test verifies the transponder's downlink encoder without relying on the correct operation of the Mode S test set.*

Verification of Test Set Error Protection Circuits

When the Mode S signal generator uses a hard keying method to generate phase reversal resulting in amplitude drop, the following method can be used to verify the Test Set Error Protection circuit.

Connect the diode detector and oscilloscope to the RF output of the test set and generate a signal strong enough to register on the oscilloscope. Synchronize with the test set interrogation rate and observe the shape of the resulting P_6 pulse. The phase transitions within P_6 will cause amplitude modulation that can be easily observed. The following combinations of texts and interrogation addresses AA will result in AP as shown:

UF=4, all fields = 0, AA = CO 51 F6 hex : AP = all ZEROs.
UF=4, all fields = 0, AA = 3F AB F2 hex : AP = AA AA AA hex.
UF=20, all fields = 0, AA = AC C5 55 hex : AP = all ZEROs.
UF=20, all fields = 0, AA = 53 3F 51 hex : AP = AA AA AA hex.

Verification of Transponder's Downlink Encoding Circuits for AP

Couple the modulation detector into the RF connection between the test set and transponder so that the transponder's reply waveform can be observed. Interrogate the transponder so that the following reply formats are generated and observe the reply pulses on the oscilloscope:

DF=5, all fields = 0, AA = 2078CE hex : AP = all ZEROs.
DF=5, all fields = 0, AA = 752D9B hex : AP = 55 5555 hex.
DF=21, all fields = 0, AA = 0B154F hex : AP = all ZEROs.
DF=21, all fields = 0, AA = 5E 401A hex : AP = 55 5555 hex.

2.5.4.1.2 Procedure #1: Error Protection, DP Field (§2.2.14.4.12, §2.2.18.2.1 and §2.2.19.1.12.6.2)

Verification of Transponder's Downlink Encoding Circuits for DP

Interrogate the transponder to extract Register 10_{16} with an interrogation having UF=4, PC=0, RR=20 (14 Hex), DI=0, IIS=0, and all remaining "SD" bits set to ZERO (0).

Check the state of bit 47 (“MB” bit 15). If bit 47 is ZERO, then the transponder does not support the Data Parity (DP) field and the following steps “a” through “j” of this procedure do not need to be performed. If bit 47 is ONE, then perform the following steps “a” through ‘j”.

a. Retain the test configuration used to perform Verification of the Transponder’s Downlink Encoding Circuits for AP in section §2.5.4.1.1.

b. Establish the conditions such that the following fields in DF=20 and DF=21 replies will be set to ALL ZERO:

   “FS”, “DR”, “UM”, “AC” in DF=20, and “ID” in DF=21

c. Establish the Discrete Address of the transponder as 5E 40 1A Hex (e.g., set AA=5E 40 1A Hex).

d. Establish the conditions where the contents of Register 40_{16} and $5F_{16}$ are set to ALL ZERO.

e. Interrogate the transponder to extract Register 40_{16} with an interrogation having UF=4, PC=0, RR=20 (14 Hex), DI=0, IIS=0, and all remaining “SD” bits set to ZERO (0).

   1. Verify that the transponder replies with a DF=20 reply having AP=96 C2 8E Hex.

   2. Repeat the interrogation with DI=3 and verify the same results.

   3. Repeat the interrogation with DI=7 and verify the same results.

f. Interrogate the transponder to extract Register 40_{16} with an interrogation having UF=5, PC=0, RR=20 (14 Hex), DI=0, IIS=0, and all remaining “SD” bits set to ZERO (0).

   1. Verify that the transponder replies with a DF=21 reply having AP=55 55 55 Hex.

   2. Repeat the interrogation with DI=3 and verify the same results.

   3. Repeat the interrogation with DI=7 and verify the same results.

g. Interrogate the transponder to extract Register 40_{16} with an interrogation having UF=4, PC=0, RR=20 (14 Hex), DI=0, IIS=0, Bit 28=1 (e.g., OVC=1), and all remaining “SD” bits equal to ZERO (0).

   1. Verify that the transponder replies with a DF=20 reply having DP=D6 C2 8E Hex.

   2. Repeat the interrogation with DI=3 and verify the same results.

   3. Repeat the interrogation with DI=7 and verify the same results.

h. Interrogate the transponder to extract Register 40_{16} with an interrogation having UF=5, PC=0, RR=20 (14 Hex), DI=0, IIS=0, Bit 28=1 (e.g., OVC=1), and all remaining “SD” bits equal to ZERO (0).

   1. Verify that the transponder replies with a DF=21 reply having DP=15 55 55 Hex.

   2. Repeat the interrogation with DI=3 and verify the same results.

   3. Repeat the interrogation with DI=7 and verify the same results.

i. Interrogate the transponder to extract Register $5F_{16}$ with an interrogation having UF=4, PC=0, RR=21 (15 Hex), DI=0, IIS=0, RRS=F Hex, Bit 25=0, LOS=0, Bit 27=0, Bit 28=1 (e.g., OVC=1), and all remaining "SD" bits set to ZERO (0).

1. Verify that the transponder replies with a DF=20 reply having DP=C9 C2 8E Hex.
2. Repeat the interrogation with DI=3 and verify the same results.
3. Repeat the interrogation with DI=7 and verify the same results.

j. Interrogate the transponder to extract Register $5F_{16}$ with an interrogation having UF=5, PC=0, RR=21 (15 Hex), DI=0, IIS=0, RRS=F Hex, Bit 25=0, LOS=0, Bit 27=0, Bit 28=1 (e.g., OVC=1), and all remaining "SD" bits set to Zero (0).

1. Verify that the transponder replies with a DF=21 reply having DP=0A 55 55 Hex.
2. Repeat the interrogation with DI=3 and verify the same results.
3. Repeat the interrogation with DI=7 and verify the same results.

2.5.4.2 Procedure #2: Interrogation Acceptance Test

(§2.2.18.2.2 – acceptance, Level 1 transponder)
(Figure 2-12 – flowchart, Level 1 transponder)
(§2.2.18.2.3 – coordination, Level 1 transponder)
(§2.2.18.2.2 – acceptance, minimum data link transponder)
(Figure 2-15 – flowchart, all data link transponders)
(§2.2.19.1.4 – coordination, minimum data link transponder)
(§2.2.20.1.1 – coordination, ELM)

Interrogation-Reply Coordination, ATCRBS and ATCRBS/Mode S All-Call

Interrogate transponder with:

ATCRBS Mode A.
ATCRBS Mode C.
ATCRBS Mode A/Mode S All-Call.
ATCRBS Mode C/Mode S All-Call.
ATCRBS Mode A-Only All-Call.
ATCRBS Mode C-Only All-Call.

Repeat all the above and include the P_2 suppression pulse.

Verify: Proper reply and reply format or no reply, as required.

Interrogation-Reply Coordination, Mode S Formats (P_6-Formats)

Interrogate transponder with all Mode S formats: UF=0 to UF=24.

For UF=0, 16 use both RL codes 0 and 1.
For UF=4, 5, 20, 21 use all RR codes 0 through 31.
For UF=24, use RC=2 in order to get a reply. For UF=11, use interrogation address FF FFFF hex.

For all other interrogations, use the interrogation address to which the transponder has been set.

Verify: Proper reply and reply format as required for this transponder design.

Proper non-reply to unspecified formats and uplink formats for which the transponder is not equipped.

Proper non-reply if the transponder design cannot generate the reply format demanded by RR or RL.

Non-acceptance conditions not covered in this test are verified elsewhere as follows:

Buffers full – §2.5.4.15
Wrong Address – §2.5.4.9
Broadcast but short format – §2.5.4.16
Lockout – §2.5.4.3 and §2.5.4.4
PR function, stochastic – §2.5.4.5

2.5.4.3 Procedure #3 CA Verification

(§2.2.14.4.6)

A separate test sequence is not required. The following tests may be combined with the FS test in Procedure #7, interrogation acceptance in Procedure #2 and whenever a squitter is encountered.

a. For Level 1 Transponders (§2.2.14.4.6 and §2.2.18.2.8):

Do not provide airborne/ground information to the transponder. Interrogate the transponder with UF11 Mode S format. Verify that CA=0 in DF=11 replies and in acquisition squitter.

For transponder with an automatic means to determine on-the-ground, set the transponder airborne. Interrogate the transponder with UF=11 Mode S format. Verify that CA=0 in DF=11 replies and in acquisition squitter.

Set the transponder on the ground. Verify that CA=0 in acquisition squitter

b. For Transponders Level 2 or above:

Provide the minimum information to the transponder. If the transponder supports TCAS do not connect TCAS. Do not provide information about ground status. Wait for Comm-B broadcast to expire (DR=0). Interrogate the transponder with UF=11 Mode S format. Verify that CA=6 in DF=11 replies and acquisition squitters.

Change the data-link capability report or the Aircraft Identification to generate a Comm-B broadcast (DR not equal to 0). Verify that CA=7 in DF=11 and acquisition squitters.

Wait for the Comm-B broadcast to expire. Provide information in order to set FS=2 (alert airborne). Verify that CA=7 in DF=11 and acquisition squitters.

Remove the condition for FS=2 and verify that CA=6. Provide information in order to set FS=4 (alert & SPI). Verify that CA=7 in DF=11 and acquisition squitters.

Remove the condition for FS=4 and verify that CA=6. Provide information in order to set FS=5 (SPI). Verify that CA=7 in DF=11 and acquisition squitters.

Remove the condition for FS=5 and verify that CA=6. Set the transponder to on-the-ground. Wait for Comm-B broadcast to expire (DR=0). Verify that CA=4 in acquisition squitters.

Change the data-link capability report or the Aircraft Identification to generate a Comm-B broadcast (DR not equal to 0). Verify that CA=7 in acquisition squitters.

Wait for the Comm-B broadcast to expire. Provide information in order to set FS=3 (alert on the ground). Verify that CA=7 in acquisition squitters.

Remove the condition for FS=3 and verify that CA=4. Provide information in order to set FS=4 (alert & SPI). Verify that CA=7 in acquisition squitters.

Remove the condition for FS=4 and verify that CA=4. Provide information in order to set FS=5 (SPI). Verify that CA=7 in acquisition squitters.

Remove the condition for FS=5 and verify that CA=4. Set the transponder airborne. Wait for the Comm B broadcast to expire (DR=0). Interrogate the transponder with UF=11 Mode S format. Verify that CA=5 in DF=11 replies and acquisition squitters.

Change the data-link capability report or the Aircraft Identification to generate a Comm-B broadcast (DR not equal to 0). Verify that CA=7 in DF=11 and acquisition squitters.

Wait for the Comm-B broadcast to expire. Provide information in order to set FS=2 (alert airborne). Verify that CA=7 in DF=11 and acquisition squitters.

Remove the condition for FS=2 and verify that CA=5. Provide information in order to set FS=4 (alert & SPI). Verify that CA=7 in DF=11 and acquisition squitters.

Remove the condition for FS=4 and verify that CA=5. Provide information in order to set FS=5 (SPI). Verify that CA=7 in DF=11 and acquisition squitters. Remove the condition for FS=5 and verify that CA=5.

c. For Transponders supporting TCAS

Provide TCAS RA information. Verify that CA=7 in DF=11 and acquisition squitters. Remove the TCAS RA condition and verify that CA=5.

2.5.4.4 Procedure #4 Non-Selective Lockout Tests

(§2.2.18.2.4)

Non-selective lockout is initiated on receipt of a correctly addressed interrogation UF=4, 5, 20, 21 containing PC=1 or LOS=1 together with IIS=0. This starts the T_D timer which holds the lockout condition for 18 ±1.0 seconds.

Non-selective Lockout applies to both (8 and 21 microseconds) ATCRBS/Mode S All-Calls and to UF=11 with IC and CL=0.

The lockout state is verified by interrogating with the locked-out All-Call types and by observing that a reply is not generated.

The lockout duration is verified by interrogation with the locked-out All-Call types 100 milliseconds before the earliest permissible timer runout and by observing that a reply is not generated.

The lockout termination is verified by interrogation with the locked-out All-Call types 100 milliseconds after the latest permissible timer runout and by observing that a reply is generated.

The timer restart feature is verified by transmitting a second lockout command while the lockout is still in effect and by observing that lockout termination occurs after the latest permissible timer runout reckoned from the last lockout command.

Negative tests verify that interrogation patterns not specifically designated as lockout commands do not cause a lockout condition in the transponder, and that lockout affects only the specified formats.

2.5.4.4.1 Positive Tests

Interrogate with UF=4, DI=3, PC=1.

Verify: Lockout state, lockout duration, lockout termination.

Repeat with UF=5, PC=1 for Level 1 transponder. Repeat with UF=5, UF=20, UF=21 and PC=1 for all other designs.

Repeat, using LOS=1 with IIS=0 as the lockout command.

Repeat with UF=4, DI≠3, PC=1.

Recommended Test Sequence:

Item	Time (sec)	Action
A	0	Interrogate with UF=4, PC=1.
B	0.02	Verify lockout with ATCRBS Mode A/Mode S All-Call.
C	0.04	Verify lockout with ATCRBS Mode C/Mode S All-Call.
D	0.06	Verify lockout with UF=11, PR=0, IC=0, CL=0.
E	16.9	Repeat items B, C, D.
F	19.1	Verify termination with ATCRBS Mode A/Mode S All-Call.
G	19.12	Verify termination with ATCRBS Mode C/Mode S All-Call.
H	19.14	Verify termination with UF=11, PR=0, IC=0, CL=0.
I	21.0	Interrogate with UF=5, PC=1.
J	21.02	Verify as in items B, C, D.
K	26.0	Interrogate with UF=20, PC=1.
L	26.02	Verify as in items B, C, D.
M	31.0	Interrogate with UF=21, PC=1.
N	31.02	Verify as in items B, C, D.
O	41.9	Verify as in items B, C, D.
P	46.9	Verify as in items B, C, D.
Q	50.1	Verify termination as in items F, G, H.

Note: *This sequence must be modified for Level 1 transponders, because they do not accept long interrogations.*

2.5.4.4.2 Required Negative Tests

a. PC Discrimination

The interrogation patterns are:

UF = 4, 5, 20, 21.
PC = 0 and DI≠3,
PC = 0 and DI=3 and LSS=1 and SIS=0,
PC = 2, 3, 4, 5, 6. 7.

Total number of patterns = 32.

With the transponder not in non-selective lockout state, interrogate with all of the above patterns consecutively. Verify that, after the sequence, the non-selective lockout state does not exist.

b. Broadcast Discrimination

The interrogation patterns are:

UF = 4, 5, 20, 21.
PC = 0, 1, 2, 3, 4, 5, 6, 7.
IIS = 0
LOS = 1

Address = Broadcast (FF FFFF hex).
Total number of patterns = 32.

With the transponder not in non-selective lockout state, interrogate with all patterns consecutively. Verify that, after the sequence, the non-selective lockout state does not exist.

c. Address Discrimination

The interrogation patterns are:

UF = 4, 5, 20, 21.
PC = 1.

Address: not for this transponder.
Total number of patterns = 4.

With the transponder not in non-selective lockout state, interrogate with all of the above patterns. Verify that, after the sequence, the non-selective lockout state does not exist.

d. II and SI Discrimination

The interrogation patterns are:

UF = 11.
PR = 0.
CL = 0 through 1, with IC = 1 through 15
CL = 2 through 4, with IC = 0 through 15.

Total number of patterns = 78.

With the transponder in non-selective lockout state, interrogate with all of the above patterns and verify that the corresponding II or SI code is not locked out.

e. All-Call Discrimination

This test verifies that the lockout state applies only to All-Call formats and not to ATCRBS or discrete interrogations. The interrogation patterns are:

All non-All-Call formats for which the transponder is designed (Procedure #2 – §2.5.4.2).

With the transponder in non-selective lockout state, interrogate with all of the above patterns and verify that they are not locked out.

2.5.4.5 Procedure #5: Selective Lockout and Independence of Non-Selective Lockout Tests

(§2.2.18.2.5)

Selective lockout is initiated on receipt of a correctly addressed interrogation UF=4, 5, 20, or 21 containing DI=1, 7; LOS=1 and IIS from 1 to 15, or DI=3, LSS=1 and SIS from 1 to 63. This starts the T_L timer associated with the received II or SI code and holds the lockout condition for 18 ±1.0 seconds.

Selective lockout applies only to UF=11 with II or SI corresponding to the running T_L timer.

Selective lockout and non-selective lockout are independent and not mutually exclusive. They can both be initiated by the same interrogation. This is done using PC=1 to start or restart the non-selective lockout timer in the same interrogation used to start or restart a selective lockout timer with any non zero IIS or SIS code.

The lockout state, duration, termination and restart are defined and tested as described in §2.5.4.4. Negative tests follow the same procedures and have the same purpose as described in §2.5.4.4.

Pattern Definition for Level 1 Transponders

Positive Interrogation Patterns Per Timer

UF: 2 codes.
DI: 2 codes with LOS=1 or 1 code with LSS=1. Total: 4 patterns for II timers, 2 patterns for SI timers starting lockout.

Total Interrogation Patterns Per Timer

UF: 2 codes.
DI: 2 codes with LOS=0,1; 1 code with LSS=0, 1
5 codes with SD field bits 23 & 26 = 1
Total: 20 possible patterns for II timers, 18 possible patterns for SI timers.

Positive test patterns: 2 or 4.
Negative test patterns: 16.

Pattern Definition of All Other Transponder Designs

Positive Interrogation Patterns Per Timer

UF: 4 codes.
DI: 2 codes with LOS=1 or 1 code with LSS=1.
Total: 8 patterns for II timers, or 4 patterns for SI timers starting lockout.

Total Interrogation Patterns Per Timer

UF: 4 codes.
DI: 2 codes with LOS= 0,1; 1 code with LSS=0,1;
5 codes with SD field bits 23 & 26 = 1
Total: 40 possible patterns for II timers, 36 possible patterns for SI timers.

Positive test patterns: 4 or 8.
Negative test pattern: 32.

Note: *The 8 negative test patterns per UF code are as follows: For each value of DI (0 – 7) set the IIS or SIS code correctly. For DI code values where there is no IIS or SIS subfield within the SD field, set the corresponding bits (bits 17-20 for IIS or 17-22 for SIS). If DI=1 or 7, set LOS=0, for all other values of DI, set bit 26=1. If DI=3, set LSS=0, for all other values of DI, set bit 23=1. Set PC=0.*

Test Sequence

Because 78 timers, each running 18 ±1.0 seconds, are involved, a test sequence is shown here that minimizes the time needed, while providing a comprehensive validation of transponder performance.

Principle of Test Sequence

A lockout timer is started by a surveillance or Comm-A interrogation and with the next interrogation, the lockout state is verified for UF=11 with the corresponding II or SI. Just before the earliest and just after the latest timer runout duration, lockout and non-lockout state is verified.

Timer intervals must be interlaced to verify their independence and to save time.

The requirement that each timer can be restarted while running must also be verified.

Independent non-exclusive operation of selective lockout and non-selective lockout is verified during the selective lockout test by setting PC=1 in some selective lockout interrogations, and verifying that the non-selective lockout and selective lockout timers operate properly.

For example: if testing the 78 selective lockout timers, for every eleventh selective timer test, set PC=1 in the interrogation. Verify proper lockout and non-lockout of the non-selective and selective timers during this selective lockout timer test.

Test #1 Multisite, T_L Timer and Lockout: Timer Duration and Insensitivity to Non-Valid Signals (All Transponders)

Time (sec)	Action
0.0	Start timer with UF=4. Include PC=1 in every eleventh selective lockout timer interrogation, i.e., for the 1st, 12th, etc., timers.
0.02	Verify lockout to timer's II or SI with UF=11.
0.04 to 1.62	Verify non-lockout to all other non-locked out IIS and SIS (times 0.9 and 1.1 will be used for the last 2 steps of the sequence for timers started previously with interlace, see *note* below), and non-lockout of the non-selective lockout during the 11th, 22nd, etc., selective lockout timer tests.
2.0	Start next timer for interlace.
3.64	Try timer restart with correct IIS or SIS and incorrect DI-LOS and DI-LSS combinations (DI:0 – 7 = 8 combinations) (see *note* above).
16.9	Verify lockout to timer's II or SI with UF=11. Verify lockout to the non-selective timer for every eleventh selective lockout timer test, i.e., the 1st, 12th, etc., tests.
19.1	Verify non-lockout. Verify non-lockout to the non-selective lockout for every eleventh selective lockout timer test, i.e., the 1st, 12th, etc., tests.

If the last test fails, the timer either runs too long or has been restarted by a non-valid signal.

Note: *Test #1 provides the basic timing of a test sequence that satisfies the principles of the test procedure while maintaining a maximum of 50 interrogations per second. Because the test sequence calls for interlacing multisite lockout timers (in this case one is started every 2 seconds), the above sequence will need to accommodate the critical timer verifications that occur at 16.9 and 19.1 seconds relative to the start of each timer. When the test sequence reaches 16.9 and 19.1 seconds after the start of each timer it will be 0.9 and 1.1 after the start of a new timer. Priority is given to verify the lockout of the earlier timer at the correct time, while the verification of non-lockout to all other timers is scheduled around these critical measurements.*

Test #2 Multisite T_L Timer and Lockout: Restart Capability and Sensitivity to All Valid Formats (All Transponders)

Time (sec)	Action
0.0	Start timer with UF=4.
0.02	Verify lockout to timer's II or SI.
4.5	Restart timer with UF=5.
21.4	Verify lockout for timer's II or SI.
23.6	Verify non-lockout for timer's II or SI.

Interlace all timers in approximately 0.3-second intervals.

For Level 2 transponders and above, alternate using UF=4 and UF=20 interrogations to start the timers, and alternate using UF=5 and UF=21 interrogations to restart timers. To test non-exclusive operation of selective lockout and non-selective lockout, here is an example. During the fifth sequence of this test set PC=1 for the start and restart timer interrogations (PC=0 for all other interrogations) and verify lockout at 0.02 and 21.4 seconds for both the selective and non-selective timers and non-lockout at 23.6 seconds for both the selective and non-selective timers.

If the test at 21.4 seconds fails, the timer has not been restarted.

Test #3 - Broadcast Discrimination related to IIS

Run test for each IIS, using interrogations with broadcast address
FF FF FF {HEX}

Time (sec)	**Action**
0.00	Interrogate with UF=20, DI=1, LOS=1.
0.02	Verify non-lockout to IIS (reply to UF = 11).
0.04	Start timer with UF=21, DI=1, LOS=1.
0.06	Verify non-lockout to IIS (reply to UF = 11).

Test #4 - Broadcast Discrimination related to SIS

Run test for each SIS, using interrogations with broadcast address
FF FF FF {HEX}

Time (sec)	**Action**
0.00	Interrogate with UF=20, DI=3, LSS=1.
0.02	Verify non-lockout to SIS (reply to UF = 11).
0.04	Interrogate with UF=21, DI=3, LSS=1.
0.06	Verify non-lockout to SIS (reply to UF = 11).

Note: *Any other test procedure not involving lockout may be run simultaneously with Test #1 as long as the tests do not interfere with each other.*

2.5.4.6 Procedure #6 Squitter Verification

(Subparagraph §2.2.18.2.6)

The squitter function of the transponder **shall** be tested to verify that the transponder correctly generates squitters at the proper rate and with the proper content. Squitters will occur randomly throughout operation of all test procedures. Squitters should be noted by the reply receiver and the test controller as unsolicited replies. Provisions should be made in the test setup to detect squitters, both acquisition and Extended Squitters, and verify their content and rate. If a squitter is detected during the operation of any of the test procedures in this document, the procedure should delay the next scheduled interrogation so that it doesn't overlap the squitter and go undetected by the transponder. The following subparagraphs contain test procedures and expected results that vary according to the aircraft installation for which the transponder is designed, those that support automatic detection of on-the-ground status and those that do not. If a transponder design allows either installation type, the test procedure should be conducted with the transponder switched to support automatic on-the-ground detection and repeated with the transponder switched for installation without automatic on-the-ground detection.

2.5.4.6.1 Acquisition Squitter Verification

The following test **shall** verify proper transmission of Acquisition squitters when the transponder is not transmitting Extended Squitters. The following tests **shall** be conducted with no external data input to the Extended Squitter GICB registers.

Step 1: Setup the transponder to airborne status. The Acquisition squitter transmission **shall** be verified to be at random intervals that are uniformly distributed between 0.8 and 1.2 seconds with a time quantization less than or equal to 15 milliseconds. The test setup will require measuring the time difference between successive Acquisition squitters. The time interval measured between successive Acquisition squitters **shall** be counted in individual 15 millisecond bins between 0.8 and 1.2 seconds. Validation of the proper quantization is achieved upon receipt of at least one Acquisition squitter in each 15 millisecond time bin between 0.8 and 1.2 seconds. Improper times are those occurring outside of the time bins between 0.8 and 1.2 seconds. Verify that the Acquisition squitters are at random intervals that are uniformly distributed over the interval between 0.8 and 1.2 seconds.

Step 2: Verify the content of the CA, AA and PI fields. For diversity transponders, verify that the squitters occur alternately from both channels. For transponders that are designed for aircraft installations with automatic means of determining on-the-ground condition, when the transponder is in on-the-ground status, verify that Acquisition squitters occur on the top antenna only at the prescribed rate.

2.5.4.6.2 Extended Squitter Verification

Extended squitters occur randomly at rates determined by internal states of the transponder. Each Extended Squitter type must be separately verified for content, rate and antenna selection which are dependent upon transponder air/ground state and Extended Squitter ground station interrogations. The selection of airborne or surface position formats is dependent upon determination of on-the-ground status and ground station control via interrogation content. The following tests **shall** be performed to verify proper operation of the transponder Extended Squitter functions. The external data sources for Extended Squitter loading **shall** be connected via the appropriate interfaces.

2.5.4.6.2.1 Extended Squitter Rate Verification

a. Verify Extended Squitter Message Rate and Timeout functions by demonstrating successful completion of all test procedures called out in §2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A, as required by §2.2.23.1.4.2.1.

   Note: *§2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A indicates that ADS-B Message Timeout performance is tested in §2.4.3.3.2.2 through §2.4.3.3.2.8.2. These same test procedure sections verify the Message Rate in RTCA DO-260B / EUROCAE ED-102A.*

b. Verify Extended Squitter Message Rate and Termination functions by demonstrating successful completion of all test procedures called out in §2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A, as required by §2.2.23.1.4.2.2.

Note: *§2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A indicates that ADS-B Message Termination performance is tested in §2.4.3.3.2.2 through §2.4.3.3.2.8.2. These same test procedure sections verify the Message Rate in RTCA DO-260B / EUROCAE ED-102A.*

c. While performing the test procedures specified in subparagraphs "a" and "b" above, verify the content of the CA, AA and PI fields in the Extended Squitter Messages.

d. For diversity transponders, setup the transponder to transmit airborne format Extended Squitters. Verify that each Extended Squitter type identified in §2.2.23.1.2 occur alternately from both channels. For transponders that are designed for aircraft installations with automatic means of determining on-the-ground condition, set the transponder to on-the-ground status and verify that Extended Squitters occur on the top antenna only at the prescribed rates.

2.5.4.6.2.2 Extended Squitter Protocol Verification

The following test verifies the transponder properly transmits Extended Squitters according to the protocol specified in §2.2.23.1.

Verify the content of the CA, AA and PI fields of all Extended Squitter replies. For the following test, connect the transponder to the appropriate source that provides altitude code input to the transponder. Also, as required, setup to provide Extended Squitter data to ground initiated Comm-B Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, 09_{16}, $0A_{16}$, 62_{16} and 65_{16} through an external interface as specified in §2.2.13.2.

Unless otherwise noted, for the following steps, setup the transponder to not inhibit Acquisition squitters and to report barometric pressure altitude in the airborne position report (subfield ATS equals ZERO). For transponders that support automatic detection of air/ground state, set the transponder to airborne state.

Step 1 Disable altitude code and all other Extended Squitter data into the transponder. Set the ALT switch to the "off" position. Upon power-up initialization of the transponder, verify that the transponder broadcasts Acquisition squitters but does not broadcast Extended Squitters. Interrogate the transponder with ground initiated Comm-B requests with RR=16, DI=7 and RRS=5, 6, 7 and 9 respectively. Verify that the MB field of the corresponding replies is ZERO. Set the ALT switch to the "on" position. Verify that the transponder continues to broadcast Acquisition squitters but does not broadcast Extended Squitters.

Step 2 Set the ALT switch to the "on" position and provide altitude code input to the transponder. After power-up initialization, verify that the transponder does not broadcast Extended Squitters. Interrogate the transponder with ground initiated Comm-B requests with RR=16, DI=7 and RRS=5, 6, 9 and 10 respectively. Verify that the altitude is ZERO in the airborne position report and remaining bits are ZERO. Verify that the MB field of the remaining replies is ZERO. Interrogate the transponder with UF=4, RR=17 and DI≠7 and verify that the SCS subfield of the data link capability report is ZERO. Verify that the transponder broadcasts Acquisition squitters.

Step 3 Provide Extended Squitter updates to the transponder at a maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, 09_{16}, 62_{16} and 65_{16}. Use other than ZERO or

ALL ONEs for the airborne position report, aircraft identification report, and the airborne velocity report. Verify that the transponder broadcasts airborne position squitters, airborne identification squitters and airborne velocity squitters at the proper rate and the ME data content matches the data stored in GICB Register 05_{16}, 08_{16} and 09_{16}, respectively. Verify that the SSS and ACS subfields of the airborne position squitter are correct. Interrogate the transponder with ground initiated Comm-B requests with RR=16, DI=7 and RRS=5, 6, 7, 8 and 9, respectively. Verify that the MB field contains the proper data. Repeat except vary the data content of each GICB and verify the data content of each Extended Squitter subsequent to each register update. Interrogate the transponder with RR=17 and DI≠7 and verify that the SCS subfield of the data link capability report is one.

Step 4 Setup the transponder as in Step 3 with Extended Squitter updates to the transponder at a maximum update interval as specified in Appendix B, Table B-2-1. Place the transponder in the airborne state. Stop updates of all Extended Squitter data, except altitude information, to the transponder for GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, 09_{16}, 62_{16} and 65_{16}.

a. Verify that after 2 seconds, the Extended Squitter ME fields for GICB Register 05_{16} are ZERO with the exception of the ACS and surveillance status fields.

b. Verify that after 2 seconds the aircraft identification and category squitter (GICB Register 08_{16}) continues to be transmitted.

c. Verify that after 2 seconds only the Selected Altitude, Selected Heading or Barometric Pressure Setting subfields of the target state and status squitter (GICB Register 62_{16}) are set to ZERO. Verify that the remaining Extended Squitter ME subfields are not cleared, as they contain other integrity, mode or status information.

d. Verify that after 2 seconds the Extended Squitter ME fields of the aircraft operational status squitter (GICB Register 65_{16}) are not cleared, as they contain various integrity, mode or status information.

e. Verify that after 2.6 seconds the airborne velocity squitter is not being transmitted.

f. Place the transponder in the ground state and verify that the surface position Extended Squitter ME field (GICB Register 06_{16}) is ZERO. Repeat the setup as in Step 3 with Extended Squitter updates to the transponder at a one half second rate. Place the transponder in the airborne state. Interrogate the transponder with RR=17 and DI=7 and verify that the SCS subfield of the data link capability report is one. After all updates (except altitude information) have ceased for 10 seconds, interrogate to extract the data link capability report and verify that the SCS subfield is ZERO. Interrogate the transponder with ground initiated Comm-B requests with RR=16, DI=7 and RRS=5, 6, 7, 8 and 9 respectively. Verify that the MB fields are ZERO with the exception of the ACS field in the airborne position squitter (GICB Register 05_{16}) and the airborne identification squitter (GICB Register 08_{16}). After all updates (except altitude information) have ceased for 60 seconds, verify that airborne identification and category Extended Squitters are still being transmitted. Place the transponder in the ground state and verify that the surface position Extended Squitter (GICB Register 06_{16}) is no longer transmitted. Return the transponder to the airborne state. Verify that the acquisition squitter and airborne position squitter are broadcast. Set the ALT switch to the "off" position. Verify that the ME field of the airborne position squitter is ZERO. After 60 seconds, verify that the transponder no longer broadcasts airborne position squitters.

Step 5 Set ALT switch to the “on” position. Setup the transponder as in step 3 and provide Extended Squitter updates to the transponder at a maximum update interval as specified in Appendix B, Table B-2-1. Stop update of GICB Registers 05_{16} and 06_{16} only. After 2 seconds, verify that the ME field of the airborne position squitter is ZERO with the exception of the ACS subfield. Verify that the transponder broadcasts airborne position, aircraft identification and airborne velocity squitters at the proper rate and the ME data content matches the data stored in GICB Registers 05_{16}, 08_{16} and 09_{16}, respectively. Interrogate with RR=16, DI=7 and RRS=5, 6, 8 and 9 and verify the MB fields matches the ME field in the corresponding Extended Squitter reply. After 10 seconds, interrogate to extract the data link capability report and verify that SCS is ZERO. After 60 seconds, verify that airborne position squitters are still transmitted.

Set the ALT switch to the “off” position. Verify that the ME field of the airborne position squitter is ZERO. After 60 seconds, verify that the transponder no longer broadcasts airborne position squitters. Verify that aircraft identification and airborne velocity squitters are transmitted throughout the test at the proper rate and with the correct data content.

Step 6 Set the ALT switch to the “on” position and provide altitude code input to the transponder. Provide Extended Squitter updates to the transponder at a maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16} and 09_{16}. Verify that the ME fields of the airborne position, velocity and aircraft identification squitters match the data input. Stop updates of Extended Squitter data to the transponder for GICB Registers 08_{16} and 09_{16} only. After 15 seconds, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping updates to GICB Register 08_{16}. After 2.6 seconds, verify that the airborne velocity squitter is no longer transmitted. Interrogate with RR=16, DI=7 and RRS=5, 6, 8 and 9 and verify that the MB fields match the ME fields in the corresponding Extended Squitter reply. Specifically, verify that the MB and ME fields for Register 08_{16} continue to match the data input prior to stopping the updates to GICB Register 08_{16}. After 10 seconds, interrogate to extract the data link capability report and verify that SCS is one. After 60 seconds, verify that airborne position and aircraft identification squitters are still transmitted. Specifically, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping the updates to GICB Register 08_{16}.

Step 7 Configure the transponder to inhibit Acquisition squitters when Extended Squitters are broadcast. Prior to providing Extended Squitter updates, verify that Acquisition squitters are broadcast. Provide Extended Squitter updates at a maximum update interval as specified in Appendix B, Table B-2-1 to GICB Registers 05_{16}, 06_{16} and 08_{16} and provide altitude code input to the transponder. Verify that Extended Squitters are broadcast and Acquisition squitters are not broadcast. Verify that airborne position and aircraft identification squitters are broadcast at the proper rate and alternately on the top and bottom antenna ports as specified for airborne state if antenna diversity is supported. Additionally provide updates to GICB Register 09_{16}. Verify the broadcast of airborne position squitters, aircraft identification squitters and airborne velocity squitters at the proper rate and the ME data content matches the data stored in GICB Registers 05_{16}, 08_{16} and 09_{16}, respectively. Verify that the transponder does not broadcast Acquisition squitters.

Set the ALT switch to the "off" position and stop update to GICB Registers 05_{16}, 06_{16}, 08_{16} and 09_{16}. After 2 seconds, verify that the ME fields of the airborne position squitters are ZERO. After 2.6 seconds, verify that the airborne velocity squitter is no longer transmitted. Interrogate with UF=4, RR=16, DI=7 and RRS=5, 6, 8 and 9, respectively. Verify that the MB fields of the replies match the data of the corresponding Extended Squitter reply. Specifically, verify that the MB fields of the replies for Register 08_{16} continue to match the data that was provided prior to stopping the updates to GICB Register 08_{16}. After 60 seconds, verify that Extended Squitter airborne position squitter transmissions stop. Verify that the aircraft identification Extended Squitter transmissions are continued and that the contents of the ME field matches the data that was provided prior to stopping the updates to GICB Register 08_{16}. Verify that the transponder resumes Acquisition squitter broadcast.

Repeat above sequence except stop update to GICB Registers 05_{16} and 06_{16} only. After 2 seconds, verify that the ME field of the airborne position report is ZERO. After 60 seconds, verify that the transponder no longer broadcasts airborne position squitters and continues to broadcast airborne velocity and aircraft identification squitters. Verify that the transponder continues to inhibit the broadcast of Acquisition squitters.

Repeat above except stop update to GICB Register 09_{16} only. After 2.6 seconds, verify that the airborne velocity squitter is no longer transmitted, and after 60 seconds, verify that the Acquisition squitters are not transmitted.

Step 8 Provide data to the transponder to trigger data to be loaded into GICB Register $0A_{16}$. Verify that an Event-Driven Extended Squitter is generated with the proper data content. Repeat for all supported Event-Driven Extended Squitter Message types. Verify that the data contained in the GICB Register corresponding to the Event-Driven Extended Squitter Message type matches the data contained in the transmitted Extended Squitter. Update GICB Register $0A_{16}$ at a rate less than twice every second. Verify that an Event-Driven Extended Squitter is generated subsequent to each update with the proper data content. Vary the data content provided externally to the transponder and verify that the data content subsequent to update of the Event-Driven report is correct. Increase the update rate to exceed twice per second. Verify that the Event-Driven Extended Squitter rate does not exceed twice per second, and that the data content reflects the most recent update contents.

For the following steps, for those transponders that support automatic detection of on-the-ground status, change the transponder to on-the-ground status. Configure the transponder to not inhibit Acquisition squitters when Extended Squitters are broadcast.

Step 9 Upon power-up initialization of the transponder, verify that the transponder broadcasts Acquisition squitters at the proper rate but does not broadcast Extended Squitters. For transponders that support automatic detection of on-the-ground status and diversity, verify that Acquisition squitters occur on the top antenna port only. Interrogate the transponder with GICB requests with RR=16, DI=7 and RRS=5, 6, 8 and 9 respectively. Verify that the MB field of the corresponding replies is ZERO.

Step 10 Provide Extended Squitter updates to the transponder at a maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 08_{16}, 09_{16}, 62_{16} and 65_{16}. Use other than ZERO or all ONEs for the surface position report and the aircraft identification report. Set TRS to ZERO. For transponders that support automatic on-the-ground detection, perform the following:

1. Verify that the transponder broadcasts surface position squitters at the high rate and the ME data content matches the data stored in GICB Register 06_{16}.
2. Verify that the transponder broadcasts aircraft identification squitters and that they occur uniformly over the range of 4.8 to 5.2 seconds as specified in §2.2.23.1.3.d. Verify that the ME data content matches the data stored in GICB Register 08_{16}.
3. Verify that the transponder broadcasts aircraft operational status squitters at the rates as specified in §2.2.3.3.1.4.2 of RTCA DO-260B/EUROCAE ED-102A and that the data content matches the data stored in GICB Register 65_{16}. When transmitting the surface formats, the rate depends on whether the high or low squitter rate has been selected (see §2.2.23.1.6).
4. Verify that the transponder does not broadcast the airborne position and the airborne velocity squitter.
5. Verify that the transponder does not broadcast Acquisition squitters.
6. Stop update of GICB Registers 05_{16}, 06_{16}, 08_{16}, 09_{16} and 65_{16}. After 2 seconds, verify that the surface position squitter ME field is ZERO. After 15 seconds, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping updates to GICB Register 08_{16}.
7. After 60 seconds, verify that surface position and surface aircraft operational status squitters stop. Verify that the aircraft identification extended squitter transmissions are continued and that the contents of the ME field matches the data that was provided prior to stopping the updates to GICB Register 08_{16}. Verify that acquisition squitter transmissions resume.

For transponders that do not support automatic on-the-ground detection, verify that airborne position squitters, airborne velocity squitters and aircraft identification squitters are transmitted at the proper rate and data content. Verify that surface position squitters are not emitted. Verify that the transponder broadcasts Acquisition squitters at the proper rate.

Repeat except vary the data content of GICB Registers 06_{16} and 08_{16} and verify the data content of each Extended Squitter subsequent to each register update.

Step 11 For transponders that support automatic on-the-ground detection and can determine surface squitter rate, repeat step 10 with TRS set to 1 and verify that the surface position and aircraft identification squitters occur at the high rate. Change TRS to 2 and repeat except verify that the surface position squitter switches to the low rate and aircraft identification squitters occur uniformly over the range 9.8 to 10.2 seconds as specified in §2.2.23.1.3.d.

In all of the above steps, interrogate the transponder with a ground-initiated Comm-B request containing RR=16, DI=7 and RRS=7 and verify that the TRS and ATS subfields are reported properly.

2.5.4.6.3 Squitter Control Verification

Squitter operation is dependent upon control from Extended Squitter ground stations from interrogation content of the SD field. SD data can command the transponder to broadcast surface position squitters and control surface Extended Squitter rate and surface squitter antenna selection.

Step 1 Squitter Type Control

a. Provide pressure altitude data and Extended Squitter updates to the transponder through the appropriate external interface. Include updates to GICB Registers 05_{16}, 06_{16}, 08_{16}, 09_{16}, 61_{16}, 62_{16} and 65_{16}. Use other than ZERO or all ones for the corresponding GICB registers. Update the registers at a half second rate to prevent time out of these registers. Set TRS to ZERO or ONE and for those transponders that support automatic on-the-ground detection, set the transponder to airborne state. Throughout the following entire step:

   1. verify that CA remains equal to 5 for transponders that support automatic on-the-ground detection; otherwise verify CA remains equal to 6, and

   2. verify that the transponder continues broadcast of Acquisition squitters throughout the test alternately using the two antenna for transponders providing antenna diversity.

b. Interrogate the transponder with UF=4, PC and RR=0, DI=2, TCS=1, RCS=2, SAS=0.

   1. Verify that the transponder:

      (a). broadcasts surface position (06_{16}) and aircraft identification (08_{16}), aircraft status (61_{16}) and surface aircraft operational status (65_{16}) squitters for 15 seconds at the low rate using the top antenna,

      (b). does not broadcast airborne position (05_{16}), airborne velocity (09_{16}) or target state and status (62_{16}) squitters during the 15 second period, and,

      (c). inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 15 second period.

      (d). continues reporting airborne in the FS field.

   2. Verify that after the 15 second interval, the transponder:

      (a). reverts to broadcast of the airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}), target state and status (62_{16}) and airborne aircraft operational status (65_{16}) squitters,

      (b). resumes broadcast of the aircraft identification (08_{16}) squitter at the high rate, and

      (c) replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations.

   3. Repeat using an interrogation as above except set TCS=2 and verify that:

      (a) the transponder broadcasts surface position (06_{16}) aircraft identification (08_{16}), aircraft status (61_{16}) and surface aircraft operational status (65_{16}) squitters at the low rate for 60 seconds on the top antenna,

(b) does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period,

(c) inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period, and

(d) After the 60 second interval, verify that:

(1). the transponder reverts to broadcast of airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters alternately using the two antenna for transponders providing antenna diversity,

(2). resumes broadcast of aircraft identification (08_{16}) squitters at the high rate, and

(3). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations.

c. Interrogate the transponder with UF=4, PC and RR=0, DI=2, TCS=1, RCS=2, SAS=0.

1. Verify that the transponder:

(a). broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}) and surface aircraft operational status (65_{16}) squitters for 15 seconds at the low rate on the top antenna,

(b). does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 15 second period, and

(c). inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 15 second period.

2. Prior to the timeout of the 15 second interval, repeat interrogation. Verify that:

(a). the transponder continues broadcast of the surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}) and surface aircraft operational status (65_{16}) squitters for another 15 seconds from the second interrogation,

(b). does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the additional 15 second period after the second interrogation, and

(c). inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the additional 15 second period after the second interrogation.

3. Repeat using an interrogation as above except set TCS=2 and verify that:

(a). the transponder broadcasts surface position (06_{16}) aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the low rate for 60 seconds on the top antenna,

(b). does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period, and (c). inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period, and

(d). prior to the timeout of the 60 second interval, repeat interrogation. Verify that:

(1). the surface position (06_{16}) aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters continue for another 60 seconds from the second interrogation,

(2). does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period after the repeat interrogation, and

(3). inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period after the repeat interrogation.

d. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=1, RCS=2, and SAS=0. Within a 1 second interval, interrogate with the same interrogation except set TCS=3. Verify that the transponder:

1. stops broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.
2. resumes broadcast of the airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters,
3. resumes broadcast of the aircraft identification (08_{16}) squitter at the high rate, and
4. replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations.

e. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=0, RCS=0, and SAS=0. Verify that the transponder:

1. continues to broadcast airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,
2. continues to broadcast the aircraft identification (08_{16}) squitter at the high rate,
3. continues to reply to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and
4. does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

f. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=3, 4, 5, 6, 7, RCS=0, and SAS=0 interrogations. For each interrogation, verify that the transponder:

1. broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,
2. broadcasts the aircraft identification (08_{16}) squitter at the high rate,

3. replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and
4. does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

g. Perform the following for transponders that support automatic on-the-ground detection. Set the transponder to **on-the-ground** status. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=1, RCS=2, and SAS=0. Verify that the transponder:

1. broadcasts surface position (06_{16}) and aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters squitters for 15 seconds at the low rate,
2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 15 second period,
3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 15 second period, and
4. After the 15 second interval, verify that the transponder:
   (a). broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the low rate,
   (b). does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters, and
   (c). continues to inhibit replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations.

h. Repeat the interrogation used in Step 1.g. After one (1) second, set the transponder to the airborne state. Then verify that the transponder:

1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the low rate for the entire 15 second period,
2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 15 second period,
3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 15 second period, and
4. After the 15 second period, verify that the transponder:
   (a). broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,
   (b). broadcasts the aircraft identification (08_{16}) squitter at the high rate,
   (c). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and
   (d). does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

Step 2 Squitter Rate Control

With the equipment connected as specified in Step 1, set TRS to ZERO or ONE and for transponders that support automatic on-the-ground detection, set the transponder to the **airborne state**. Except as otherwise noted, verify that the Acquisition squitter is broadcast throughout the following step at the proper rate.

a. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=2, RCS=1 and SAS=0. Verify that the transponder:

   1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters for 60 seconds at the high rate,

   2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period,

   3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period, and

   4. After the 60 second period, verify that the transponder:

      (a). broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,

      (b). broadcasts the aircraft identification (08_{16}) squitter at the high rate,

      (c). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

      (d). does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

b. Repeat the Step 2.a procedure, except prior to the 60 second interval, repeat the interrogation with TCS=2 and RCS=1, and verify that the transponder:

   1. continues to broadcast surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the high rate for 60 seconds after the repeat interrogation,

   2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period after the repeat interrogation,

   3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period after the repeat interrogation, and

   4. After the 60 second period after the second interrogation, verify that the transponder:

      (a). broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,

      (b). broadcasts the aircraft identification (08_{16}) squitter at the high rate,

      (c). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

      (d). does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

c. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=0, RCS=1 and SAS=0. Verify that the transponder:

1. continues to broadcast airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,

2. continues to broadcast the aircraft identification (08_{16}) squitter at the high rate,

3. continues to reply to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

4. does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

d. Repeat the interrogation used in Step 2.c except use TCS = 3, 4, 5, 6, 7. For each TCS used, verify that the transponder continues to respond as in Step 2.c.

e. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=1, RCS=2, and SAS=0. Verify that the transponder:

1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the low rate for 15 seconds after the interrogation,

2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 15 second period after the interrogation,

3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 15 second period after the interrogation, and

4. After the 15 second period, verify that the transponder:

   (a). broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,

   (b). broadcasts the aircraft identification (08_{16}) squitter at the high rate,

   (c). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

   (d). does not broadcast surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

f. Repeat the interrogation used in Step 2.e, except set TCS=2. Verify that the transponder:

1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the low rate for 60 seconds,

2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period,

3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period and

4. After the 60 second period, verify that the transponder:

   (a). broadcasts airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rate,

   (b). broadcasts the aircraft identification (08_{16}) squitter at the high rate,

   (c). replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

   (d). does not broadcast surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

g. The following verifies that the RCS subfield has no effect when the transponder is not transmitting surface position squitters. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=0, RCS=1, and SAS=0. Verify that the transponder:

1. continues the broadcast of the airborne position (05_{16}), airborne velocity (09_{16}), aircraft status (61_{16}) and airborne aircraft operational status (65_{16}) squitters at the proper rates.

2. continues to broadcast the aircraft identification (08_{16}) squitter at the high rate,

3. continues to reply to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations, and

4. does not broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

h. Repeat Step 2.i above, except set RCS=2, 3, 4, 5, 6 and 7, respectively. For each setting used for RCS, verify that the transponder responds as required in Step 2.i.

i. The following verifies that reserved RCS codes have no effect when the transponder is transmitting surface position squitters. Interrogate the transponder with UF=4, PC and RR=0, DI=2, TCS=2, RCS=0, SAS=0. Verify that the transponder:

1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the proper rates,

2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period following the interrogation,

3. inhibits replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations during the 60 second period following the interrogation.

j. Repeat the interrogation used in Step 2.k, except set TCS=0 and RCS=3, 4, 5, 6 and 7, respectively, and for each setting used, verify that the transponder:

1. continues broadcast of surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters at the proper rate following each interrogation, and

2. does not broadcast airborne position (05_{16}) or airborne velocity (09_{16}) squitters during the 60 second period following the interrogation.

k. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=2, RCS=1, and SAS=0. Follow this interrogation within 1 second with the same interrogation except set TCS=3. Verify that the transponder stops broadcast of surface position (06_{16}) and surface aircraft operational status (65_{16}) squitters.

Step 3 Squitter Antenna Control

The following procedure verifies that the transponder correctly broadcasts surface Extended Squitters and Acquisition squitters on the proper antenna ports as commanded by the SAS subfield. For transponders that do not support antenna diversity, verify that the SAS commands have no impact on Acquisition or Extended Squitter transmissions.

a. With the equipment connected as specified in Step 1, for transponders that support automatic on-the-ground detection, set the transponder to **on-the-ground** status. For transponders that support automatic detection of on-the-ground condition, verify that the transponder:

   1. broadcasts surface position (06_{16}), aircraft identification (08_{16}), aircraft status (61_{16}), and surface aircraft operational status (65_{16}) squitters on the top antenna only, and

   2. does not broadcast Acquisition squitters.

b. Interrogate the transponder with UF=4, PC=0, RR=0, DI=2, TCS=0, RCS=0, and SAS=0. For transponders that do not support automatic detection of on-the-ground status, verify that the following interrogations have no impact to Extended Squitter and Acquisition squitter transmissions. Otherwise, verify that the transponder broadcasts Extended and Acquisition squitters on the top antenna only.

c. Repeat interrogation used in Step 3.b, except set SAS=1. Verify that:

   1. each Extended Squitter type and Acquisition squitters occur alternately on the top and bottom antennas, and

   2. after 120 seconds, verify that the transponder broadcasts Extended and Acquisition squitters from the top antenna only.

d. Repeat interrogation except set SAS=2. Verify that:

   1. the transponder broadcasts Extended and Acquisition squitters for 120 seconds from the bottom antenna only, and

   2. after the 120-second interval, that the transponder resumes broadcasting Extended and Acquisition squitters from the top antenna only.

e. Repeat interrogation used in Step 3.b, except with SAS=1 followed by an interrogation 10 seconds later with SAS=3. After the second interrogation, verify that the transponder resumes broadcasting Extended and Acquisition squitters from the top antenna only.

f. Repeat above procedure for transponders that support automatic on-the-ground detection, except set the transponder to **airborne state** and verify that the SAS commands have no effect on Acquisition and Extended Squitter transmissions and squitters are broadcast alternately on top and bottom antenna ports.

g. Repeat above procedure except command the transponder to report surface Extended Squitters via UF=4, PC=0, RR=0, DI=2, TCS=2, and RCS=0 interrogations every 60 seconds to maintain surface squitter transmissions. Set up transponders that support automatic on-the-ground detection to the **airborne state**. Verify that the SAS command properly controls antenna port selection for each of the Extended Squitter types as specified for each SAS value, and that the SAS commands have no effect on Acquisition squitter transmissions.

2.5.4.7 Procedure #7: FS and VS Protocol/Code Tests

The following procedure verifies the FS, VS and SSS protocol and verifies proper coding. The FS and SSS codes are dependent upon Alert conditions input to the transponder. The FS, VS and also the CA codes are dependent upon the automatically determined on-the-ground condition input to the transponder for installations so equipped.

(§2.2.14.4.15 – FS code).
(§2.2.14.4.42 – VS code).
(§2.2.23.1.8 – SSS code).
(§2.2.13.1.2.c, §2.2.18.2.7 – protocol).
(§2.2.18.2.11 – interface).
(Figure 2-17 – Flowchart).

This procedure verifies the proper operation of the FS and VS protocols and codes.

Transponder States

A = Alert Register set.
B = T_C timer runs = 16 states, independent.
C = T_I timer runs.
D = Ground Register set.

Interrogation Patterns for the Level 1 Transponder

UF=4, 5 with RR=0 = 3 patterns.
UF=0.

Interrogation Patterns for All Other Transponders

UF=4, 5, 20, 21 with RR=0 and 16 through 31.
UF=0, 16 = 70 patterns.

Transaction Summary

Level 1 Transponder:	48 transactions.
All Other Transponders:	1120 transactions.

Required Code Verification Test

Observe that the FS code follows the transponder states as specified in §2.2.14.4.15 and verify that VS=1, if and only if the "on-the-ground" input is active.

Note: *The Alert Register is set when the manual or interface input to the ID function is 7500, 7600, 7700.*

The T_C timer is started when the input to the ID function is changed.

The T_I timer is started when manual or interface input exists for SPI momentarily.

The Ground Register is set when input to the "on-the-ground" interface indicates that condition.

The transactions required for this test can be interlaced during the procedures required for interface verification or during any other convenient interval. This can be arranged so that no time is lost in waiting for the timers to run out.

Required Timer Duration Test

Duration of each timer run (T_C and T_I) must be verified to be 18 ±1.0 seconds by observation of FS code change.

Change the input of the ID function to a value other than 7500, 7600 or 7700. Verify that the Mode A Code, temporary alert is set (FS field value is 4 or 5). Five (5) seconds later, change the input of the ID function to a value other than 7500, 7600 or 7700 and different from the previously used value. Verify that the Mode A Code temporary alert is set (FS field value is 4 or 5) for 18 ±1 seconds after the second change.

On-the-Ground Validation Test

For transponders that support automatic on-the-ground condition input and either implement Extended Squitter formatting or support the on-the-ground validation requirements of §2.2.18.2.7.c, the following test **shall** be performed.

The on-the-ground input is used in determining the codes for FS, VS and CA fields. The requirements of Section §2.2.18.2.7.c utilize radio altitude, ground speed and airspeed inputs to validate the on-the-ground status when indicated by the input to the transponder. If the conditions for overriding the on-the-ground status indicated by the input to the transponder, the airborne status **shall** be utilized to select FS, VS and CA field coding. Also, for extender squitter format selection, airborne formats **shall** be transmitted unless overridden by ground station interrogation commands. CA field validation for Acquisition squitters and Extended Squitters is verified as part of Procedure #6 in §2.5.4.6, so the following test can be incorporated as part of that testing.

Setup the transponder to indicate on-the-ground status by input to the transponder. With no input of radio altitude, airspeed and ground speed to the transponder, verify that the FS codes are determined by the transponder states above with the Ground Register set to on-the-ground and VS is set to 1. Input radio altitude, airspeed and ground speed to the transponder. Since not all aircraft installations may have access to all three inputs, testing is required for all combinations of inputs being provided to the transponder so that each input is tested individually and collectively. This is to insure that any one input reporting a value that sets airborne status as specified in §2.2.18.2.7.c, properly outputs FS values according to Figure 2-17 with the Ground Register reset to NOT indicate on-the-ground condition and VS is ZERO. If all inputs are supported by the transponder, a total of 27 combinations are required. This represents 9 cases with radio altitude not input, 9 cases with a value above 50 feet and 9 cases with a value below or equal to 50 feet. The same variation for airspeed and ground speed is required except the values selected would be above 100 knots to satisfy the requirement to reset the Ground Register to NOT indicate on-the-ground condition and a value at 100 knots or below to not modify the on-the-ground status.

SSS Code Validation Test

The SSS subfield is contained in the ME field of airborne Extended Squitters. Setup the transponder to transmit airborne Extended Squitters at the nominal rates. Verify the following:

1) SSS=0 when no alert (the Alert Register is clear and T_C timer is not running) and no SPI condition is active.

2) SSS=1 when Alert Register is set and no SPI Condition is active.
3) SSS=2 when the T_C timer is running and returns to ZERO after the temporary alert has cleared after 18 ±1 seconds.
4) SSS=3 when the T_I timer is set indicating a SPI Condition is active and returns to ZERO after the T_I timer expires.
5) SSS=1 when Alert Register is set and SPI Condition is active. Clear the alert and verify that SSS=2 as T_C timer is now active. Set the SPI Condition, which will set the T_I timer. Verify that SSS=2 until the T_C timer expires. Verify that SSS=3 upon expiration of the T_C timer and that SSS=0 upon expiration of the T_I timer.
6) SSS=3 when the T_I timer is started. Prior to expiration of the T_I timer, start the T_C timer and verify that SSS=2. Upon expiration of the T_C timer, verify that SSS returns to ZERO.
7) SSS=3 when the T_I timer is started. Set the Alert Register while the T_I timer is running and verify that SSS=1.

Alert when leaving standby condition

a. Set to the airborne state and change the input of the ID function to a value other than 7500, 7600 or 7700.
b. Wait 19 seconds.
c. Set the transponder to STANDBY condition.
d. Set the transponder to return to normal condition.
e. Verify that the Mode A Code, temporary alert is set (FS field value is 2 and SSS=2 when the transponder is ES capable) for 18 ±1 seconds after leaving the STANDBY condition.
f. Repeat Steps “a” through “e”, except in Step “c” set the transponder to OFF.

Change the input of the ID function to 7500

a. Set to the airborne state and set the transponder to STANDBY condition and provide the transponder with the 7500 code.
b. Set the transponder to return to normal condition.
c. Verify that the permanent alert is set (FS field value is 2 and SSS=1 when the transponder is ES capable).
d. Repeat the test with 7600 and 7700.
e. Repeats Steps “a” through “d”, except in Step “a” set the transponder to OFF.

2.5.4.8 Procedure #8: PI (Parity/Identity) Verification

(§2.2.18.2.9)

This test procedure verifies the PI field generation.

A separate test sequence is not required.

Required Verification:

During the lockout tests, the transponder generates replies to All-Call interrogations and the reply receiver receives the PI field and extracts the II or SI code received by the transponder in the preceding interrogation.

Verify that the extracted code agrees with the II or SI of the preceding All-Call.

Verify that the extracted code equals 0 if the preceding All-Call was an ATCRBS/Mode S type.

2.5.4.9 Procedure #9: Address Tests

(§2.2.18.2.2 – addressing discrimination)
(§2.2.13.1.1.a (1) – protection of Mode S address bits)
(§2.2.13.1.1.a (2) – address reporting)
(§2.2.13.1.1.a (3) and §2.2.18.2.1.c – address encoding)
(§2.2.18.2.11 – address interface)

This test procedure verifies that the address set into the address interface of the transponder is only accepted during power-up or unit reset, that the accepted address set is actually the address to which the transponder responds, and that the accepted address is the only address which the transponder reports in DF=11. It is also verified that this accepted address pattern is used in generating the AP field of replies and that the transponder does reply only to this address.

Test Sequence:

1. Remove power from the transponder under test.
2. Set the transponder address selector device to any valid 24-bit aircraft address (not a single ZERO (0) or ONE (1)), referred to as “address #1.”
3. Apply power to the transponder under test and wait a minimum of 2 seconds.
4. Interrogate the transponder with address #1 and observe:

   Acceptance for all formats.
   Correct reporting of address # 1 in AA field of DF=11.
   Correct encoding of address # 1 in AP field of replies.

5. Interrogate the transponder with any Mode S address other than address #1 and observe:

   Non-acceptance of all formats.

6. Set the transponder address selector device to a different randomly chosen valid Mode S address (not a single ZERO (0) or ONE (1)), referred to as “address #2.”
7. Verify correct reporting of address # 1 in AA field of DF=11.
8. If the transponder is designed to monitor the Mode S address, then:
9. Verify that the transponder generates an appropriate diagnostic error message to indicate that the transponder address has changed.

10. Interrogate the transponder with address #2 and observe:

    Non-acceptance of all formats.

11. Interrogate the transponder with address #1 and observe:

    Acceptance of all formats.
    Correct reporting of address # 1 in AA field of DF=11.
    Correct encoding of address # 1 in AP field of replies.

Repeat this test with several randomly chosen valid 24-bit aircraft addresses (not a single ZERO (0) or ONE (1)) as address #1 and address #2.

2.5.4.10 Procedure #10: Altitude Report Tests

(§2.2.13.1.2.a (l) – in ATCRBS)
(§2.2.13.1.2.a (2) – in Mode S)
(§2.2.18.2.11 – interface)

This test procedure verifies that the altitude code, as it is set into the interface, appears correctly in both ATCRBS and Mode S replies.

Transponder Designs

In ATCRBS replies only 11 of the possible 13 pulses are used; X and D1 are not part of the code. Additionally, some transponders may not need the capability to transmit the D2 and/or D4 pulses, which start at 62000 and 30750 feet respectively. At the other extreme, a transponder with the capability to report altitude in meters must have the capability to transmit ONEs in all 13 bits of the AC field.

Transponders report altitude in up to six reply formats depending on the implementation level: ATCRBS Mode C, DF=0, DF=4, (Level 1 and above) the airborne position squitter, DF=17 (Extended Squitter capability), and in DF=16, and DF=20 (Level 2 and above).

Test Sequence:

Step 1: No Barometric Altitude Data

Disconnect the interface input for altitude code or do not supply altitude information if the interface is common with other data systems. Interrogate so that all possible altitude reporting downlink formats are generated in replies. For ATCRBS, verify that only the bracket pulses appear and that bits 20 through 32 of Mode S replies are ZEROs. Setup the transponder to transmit airborne position squitters and verify that the altitude field is all ZEROs.

Connect the altitude source to the interface input, generate a code consisting of all ZEROs and verify as above. Repeat the test procedure while providing invalid data and verify that the AC field is set to all ZEROs.

Step 2: Barometric Altitude Data Available

With the altitude code source connected to the interface input, apply the Barometric Altitude Input_A values provided in Table 2-13. Verify that the altitude appears correctly in all reply formats containing an altitude code, and in the Mode S replies and Extended Squitter the “Q” bit and the “M” bit are set to ZERO (0).

Apply the Barometric Altitude Input_B values provided in Table 2-13. Verify that the altitude appears correctly in all reply formats containing an altitude code, and in the Mode S replies and Extended Squitter the “Q” bit is set to ONE (1) and the “M” bit is set to ZERO (0) for cases 1 through 7. Verify that the “Q” bit and the “M” bit are set to ZERO (0) for cases 8 through 10.

Table 2-13: Barometric Altitude Data Inputs

Case #	Altitude Input_A (100 foot increments)	Altitude Input_B (< 25 foot increments)
1	– 1000	– 1012
2	– 900	– 500
3	– 200	– 12.5
4	0	0
5	800	28025
6	2800	32050
7	6800	50175
8	14800	50200
9	30800	51600
10	62800	79800

For aircraft installations that support shared interfaces and aircraft bus interfaces that provide multiple altitude data sources and types, perform the above test patterns and verify that the correct altitude source is selected. Apply all sources of altitude data that are available to the transponder and verify the following: 1) the proper pressure altitude input is selected the data is referenced to the standard pressure setting of 1013.25 hectopascals (uncorrected pressure altitude), 2) that if 25-foot or better pressure altitude sources are available, pressure altitude is reported in 25-foot increments. Verify that if 25 foot or better pressure altitude sources are not connected or are not available, that 25-foot altitude is not reported.

Step 3: Data Provided in Metric, If Available

Repeat Step 2 with the input indicating metric input, if available, and verify that the "M" bit is set to 1 in the AC field of all replies.

2.5.4.11 Procedure #11: 4096 Code Tests

(§2.2.13.1.2.b)
(§2.2.18.2.11 – interface, electrical)
(§2.1.7.a – interface, manual)

This test verifies that the 4096 code set by the pilot appears correctly in both ATCRBS and Mode S replies.

Procedure Selection:

For all installations and transponder designs, the initial input of the code is set manually by the pilot. The code selector device may or may not be an integral part of the transponder. If an electrical input exists, it may be dedicated to this function alone, or it may be common with other data systems. Any procedure selected ultimately must be traceable to the manual input mode, even if the pilot's selector device is provided by another manufacturer.

Pattern Selection:

The correlation between pulse position in ATCRBS and bit number in Mode S replies is shown in §2.2.13.1.2.b.

Only 12 of the possible 13 pulses or bit positions are used; X(26) is not part of the code. Test patterns are chosen so that the most likely failure modes (incorrect wiring in connectors, cables, code switches or register malfunction) are likely to be found. The following systematic test pattern generation is required:

There exist 66 code patterns consisting of two ONEs and 10 ZEROs, while another 66 patterns have two ZEROs and 10 ONEs. These 132 patterns are used for verification because they assure that a pair of connections is not defective. (A sequence of randomly chosen patterns is not suitable because there are many incorrect wiring possibilities and a random test can fail to detect errors).

The correlation between the required test pattern and the actual code numbers as seen by the pilot follows:

4096 Codes That Produce Two ONEs and 10 ZEROs

0003	0202	1400
0005	0204	2001
0006	0210	2002
0011	0220	2004
0012	0240	2010
0014	0300	2020
0021	0401	2040
0022	0402	2100
0024	0404	2200
0030	0410	2400
0041	0420	3000
0042	0440	4001
0044	0500	4002
0050	0600	4004
0060	1001	4010
0101	1002	4020
0102	1004	4040
0104	1010	4100
0110	1020	4200
0120	1040	4400
0140	1100	5000
0201	1200	6000

4096 Codes That Produce Two ZEROs and 10 ONEs

1777	6577	7576
2777	6677	7637
3377	6737	7657
3577	6757	7667
3677	6767	7673
3737	6773	7675
3757	6775	7676
3767	6776	7717
3773	7177	7727
3775	7277	7733
3776	7337	7735
4777	7357	7736
5377	7367	7747
5577	7373	7753
5677	7375	7755
5737	7376	7756
5757	7477	7763
5767	7537	7765
5773	7557	7766
5775	7567	7771
5776	7573	7772
6377	7575	7774

Transponder Designs:

The Level 1 transponder reports the 4096 code in ATCRBS Mode A replies and in DF=5; 264 replies must be verified.

All other transponders report the 4096 code in ATCRBS Mode A replies and in DF=5, 21; 396 replies must be verified.

Test Sequence:

Enter all test patterns manually or electrically and verify that they are correct in both ATCRBS and Mode S replies.

If the test patterns are entered electrically, a corresponding test procedure must be devised to verify the connection between 4096 codes and the electrical input to the transponder. This should include cables and connectors.

If the electrical input simulates an on-board data distribution system, the verification procedures for that system govern the above verification.

A manual insertion of the 4096 codes can be prompted by an interactive readout from the controller to speed the procedure.

2.5.4.12 Procedure #12: RI, Acquisition and Maximum Airspeed

(§2.2.13.1.1.b – insertion)
(§2.2.14.4.33 – code)
(§2.2.18.2.11 – interface)
(§2.2.22.1.5)

This test procedure verifies that the airspeed code as it is set at the fixed direct data interface appears correctly in replies and that it appears only when the interrogation shows AQ=1.

Pattern Selection:

Of the 4 bits of the RI field, one (bit 14) is controlled by the content of the received interrogation. The remaining three (bits 15 – 17) show the airspeed code from the fixed direct data interface when bit 14 is ONE, and input from a variable data interface when bit 14 is ZERO. This procedure concerns only the fixed data interface; RI action for the variable data interface is verified in Procedure #17.

To be verified are code 0 and codes 8 through 14 of §2.2.14.4.33.

Transponder Designs:

The airspeed codes range to 1200 knots. Bit 15, if ONE, characterizes all airspeeds above 300 knots. Transponders may not have inputs for airspeeds above that limit.

The Level 1 transponder requires interrogations with UF=0, AQ=0, 1 and RL=0 (2 interrogation patterns).

All other transponders require interrogations with UF=0, 16, AQ=0, l and RL=0, l (8 interrogation patterns).

Test Sequence:

For each airspeed code (for which the transponder is equipped), interrogate with the required number of patterns and verify that the RI field shows the code according to §2.2.14.4.33 or §2.2.22.1.5, as appropriate.

Note: *Since some transponders may enter the airspeed code through a common on-board data system, a corresponding test procedure must be used.*

2.5.4.13 Procedure #13: PR, Probability of Reply, Stochastic Acquisition

(§2.2.14.4.31 – PR code)
(§2.2.18.2.2.i – protocol)

This test procedure verifies that the probability-of-reply decision for All-Call interrogations is carried out correctly.

Principle of Test Procedure:

A large number of Mode S-only All-Call interrogations (UF=11) are made for each of the PR codes. For each PR code, a specified fraction of the interrogations will result in a reply. One hundred interrogations would provide a valid sample for active PR codes while a lesser number would be adequate for other codes.

Transponder Designs:

This test applies to all transponder designs.

Test Sequences:

a. Transponder Not Locked Out to All-Calls

Interrogate with UF=11 according to the summary below and verify the number of replies received as indicated:

Number of Interrogations	PR =	Replies	
		No Less Than	No More Than
100	0	99	100
100	1	35	65
100	2	18	32
100	3	9	15
100	4	4	8
20	5		0
20	6		0
20	7		0
100	8	99	100
100	9	35	65
100	10	18	32
100	11	9	15
100	12	4	8
20	13		0
20	14		0
20	15		0

Note: *This test is based on a small sample, and is likely that in some cases of testing, statistical variation may cause a correctly implemented transponder to fail this test. In this case, it is equally likely that if the test is rerun one or more times, it may then be successful.*

b. Transponder Locked Out to All-Calls

The transponder can be in 79 different specific lockout states as determined by the running of the one T_D and the 78 T_L timers. The following test sequence must be repeated for each of the lockout states:

Interrogate so that the transponder is locked out non-selectively or selectively as required.

Interrogate with UF=11, containing II corresponding to the existing lockout state, and verify the number of replies according to the summary below:

Number of Interrogations	PR =	Replies	
		No Less Than	No More Than
20	0		0
20	1		0
20	2		0
23	3		0
20	4		0
20	5		0
20	6		0
20	7		0
100	8	99	100
100	9	35	65
100	10	18	32
100	11	9	15
100	12	4	8
20	13		0
20	14		0
20	15		0

Squitter Precaution

Because squitters, which have the same format, can distort the results of this test, precautions must be taken. Therefore, the test should be conducted during the 800-millisecond periods following squitter (§2.5.4.6).

Note: *It is not necessary that this test consist of an uninterrupted sequence of All-Calls. The interrogations can be dispersed throughout the overall test procedure whenever convenient.*

2.5.4.14 Procedure #14: Not Used

2.5.4.15 Procedure #15: Comm-A, Interface and Information Content

(§2.2.19.1.10 – protocol)
(§2.2.13.3.1.a – content)
(§2.2.13.3.1.b – no-storage design)
(§2.2.13.3.1.c – storage design)
(§2.2.13.3.1.d – non-acceptance)
(§2.2.3.4.2 – acceptance rate)
(§2.2.19.1.1.b – broadcast)

This procedure verifies that the information contained in Comm-A interrogations passes out of the transponder within the specified time interval and that such information correctly replicates the received transmission.

In this test, the equipment must monitor both the reply content via the reply received, and the uplink interface output via the interface adapter.

Interrogation Patterns:

UF = 20, 21.
RR = 0.
MA = 3080 different patterns, half containing two ONEs, half containing two ZEROs.

Address: Use the broadcast address for 5% of the interrogations.

Total number of interrogations if UF=20 and UF=21 are alternated: 3080.

Test Sequence A:

Interrogate at the normal (50/sec) rate, alternating UF=20 with UF=21 inserting RR=0 to 15, PC=0 to 7, DI=0 to 7 and SD=random. Insert the 3080 different patterns into MA. Verify that the uplink content, as transmitted, appears at the interface in the same order as transmitted.

Note: *If the interface is of the storage design, the information may be delayed; coordination with the interface design is required.*

Test Subsequence:

Within the test sequence above, make 100 interrogations in 2.0 seconds. Schedule bursts and timing are as follows:

Start of Burst (ms)	**Number of Interrogations**	**Interrogation Rate (per sec)**
0	4	2500
80	4	2500
160	8	320
320	8	320
480	8	320
640	18	180
1000	4	2500
1080	4	2500
1160	8	320
1320	8	320
1480	8	320
1640	18	180

For the non-storage design, verify compliance with §2.2.13.3.1.b.

For the storage design, verify that within two seconds of this subsequence all uplink content appears in proper order as transmitted at the interface terminals.

Test Sequence B (Buffer Full)

Within one second, generate interrogation bursts as shown below. Use short replies to remain within the reply capability of the transponder.

Start of Burst (ms)	Number of Interrogations	Interrogation Rate (per sec)
0	4	2500
80	4	2500
160	8	320
320	8	320
480	8	320
640	18	180
750	16	180

Note: *This sequence is chosen so that the minimum data transfer rate of a storage type interface is exceeded.*

One second after the first burst, verify that the content of at least the first 50 interrogations has appeared at the interface.

This test applies only if a storage design has been used.

2.5.4.16 Procedure #16: Broadcast Formats

(§2.2.19.1.1.b)

The broadcast function is verified as part of Procedure #15. A negative test must be conducted to verify that the broadcast function does not occur when short formats are used.

Patterns and Sequence:

Interrogate with UF=0, 4, 5 and a broadcast address. Verify that no information transfer occurs at uplink interfaces as a result of these interrogations.

2.5.4.17 Procedure #17: Downlink Interface, DFs 0, 16

(§2.2.13.3.1, a and b – interface)
(§2.2.19.1.16 – protocol)
(§2.2.14.4.26 – MV)
(§2.2.22.1.4)

This test procedure verifies that bit insertion into the first 32-bit positions of Mode S replies is possible and is carried out without disturbing established fields or protocols.

This test procedure also verifies that bit patterns inserted into the MV field of DF=16 are transmitted as inserted.

Transponder Design:

The downlink interface for DFs 0 and 16 can exist as a separate port or as one direction of a bidirectional un-buffered (real time) port. It can also exist as an interface accepting only the bit insertion for DF=0 (short reply).

All data link transponders use DF=0 and DF=16.

Note: *In TCAS installations, it is possible that a separate interface, according to §2.2.19.1.16, exists for UF=DF=0, 16. Such an interface may not be accessible if TCAS and transponder functions are integrated. In such circumstances, the test procedures for TCAS* ***shall*** *govern.*

Patterns for DF=0, 16

Unconditional Insertion

The locations are:

Bits 9, 10, 11: a total of 3 bits.

Interface patterns:

There are 8 possible unconditional interface patterns to be verified based on these 3 bits.

Interrogation patterns:

UF=0, RL=0, AQ=1, DS=0.
UF=16, RL=1, AQ=1.
UF=0, RL=1, AQ=1, DS any value other than 0.

Conditional Insertion

The locations are:

Bits 15, 16, 17: These can be inserted only if the interrogation contained AQ=0.

Interface patterns:

There are 8 possible conditional interface patterns to be verified based on these 3 bits.

Interrogation patterns:

UF=0, RL=0, AQ=0, DS=0.
UF=16, RL=1, AQ=0.
UF=0, RL=1, AQ=0, DS any value other than 0.

Note: *The interrogation that includes a DS value other than ZERO will test that the reply bits are not affected by TCAS Crosslink protocol. The data content inserted in the ground-initiated Comm-B registers being tested should be other than ALL ZEROs or ALL ONEs.*

Positive Test Sequences for DF=0, 16

Unconditional Insertion

For each interrogation pattern, generate 8 interrogations while sequencing through all 8 possible interface patterns. Verify that the replies contain bits as inserted.

Conditional Insertion

For each interrogation pattern, generate 8 interrogations while sequencing through all 8 possible interface patterns. Verify that the replies contain bits as inserted.

Negative Test Sequence for DF=0, 16

Disconnect the interface input for the airspeed report or enter code 0 for airspeed. Insert ONEs for bits 14 through 17 at the downlink interface and interrogate with UF=0, RL=0, AQ=1 and with UF=16, RL=1, AQ=1.

Verify that bits 15 through 17 of the replies are ZEROs.

MV Test Sequence for All Data Link Transponders

This test sequence includes all unconditionally inserted bits in addition to the bit patterns of the MV field.

Interface Patterns and Test Sequence

Using bits 9 through 11 and 41 through 58, generate 420 interface patterns, 210 containing two ONEs and 210 containing two ZEROs.

Interrogate to extract replies of the inserted patterns and verify that they are transmitted as inserted. In the case of the interrogation with DS other than ZERO, verify that the MV field contains the data of the ground-initiated Comm-B register corresponding to the DS value in the interrogation.

Note: *The MV field will only contain the requested Comm B data if the transponder is TCAS Crosslink Capable and the requested register is supported by the transponder.*

2.5.4.18 Procedure #18: Comm-B Protocol

(§2.2.19.1.12 through §2.2.19.1.12.4)
(§2.2.19.2.2 through §2.2.19.2.3.1)
(§2.2.19.2.3.3 through §2.2.19.2.3.5)
(§2.2.19.2.1.2 – UM)
(Figure 2-20 – Flowchart)

This test procedure verifies that the Comm-B protocol is carried out correctly.

The test procedure follows the notation of transponder states and of interrogation patterns as shown in the flowchart.

Transponder States

The transponder states are defined by the combinations of conditions E through I, where:

E = B-register set: B-bit inserted.
F = T-register set: Message has been transmitted.
G = Timer runs: For multisite only.
I = Next message waiting.

There are six possible states as shown below:

#	E	F	G	I	
1	0	0	0	0	No B-bit, others impossible or inconsequential.
2	1	0	0	0	B-Register set, message not extracted
3	1	1	0	0	Message extraction, not multisite protocol.
4	1	1	0	1	As above, next message waiting.
5	1	1	1	0	In multisite, interrogation with wrong IIS can not close out.
6	1	1	1	1	In multisite, next message waiting

State 5 must be tested with all 15 IIS codes.

It is not necessary to test State 6 with all IIS codes with all interrogation patterns. However, the IIS used in the multisite reservation should be changed each time the transponder has to be returned to State 6 after a previous interrogation pattern that changed it to another State.

Interrogation Patterns

#	A	B	C	D	K	L	
1	0	0	0	0	0	0	Ordinary interrogation, asking for short reply.
2	0	0	0	0	0	1	Ground-initiated Comm-B extraction (FIS etc).
3	0	0	0	0	1	0	Air-initiated Comm-B extraction, not multisite. For State 2, run 2 cases, one use any interrogation to satisfy condition K with DI≠3 and the second case use RR=16 with DI=3 and RRS=0.
4	0	1	0	0	0	0	Multisite, but not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
5	0	1	0	0	0	1	Ground-initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
6	0	1	0	0	1	0	Air-initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
7	0	1	0	1	0	0	Multisite closeout for Comm-B. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use all 16 IIS codes)
8	0	1	0	1	0	1	Multisite closeout for Comm-B and ground initiated Comm-B extraction. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use one incorrect IIS and the correct IIS)
9	0	1	0	1	1	0	Multisite closeout for Comm-B and attempt to extract a possible message still waiting at the air-initiation interface. (IIS sensitive: States 2-4 use IIS=0 and IIS≠0, State 5 use one incorrect IIS and the correct IIS)
10	0	1	1	0	0	0	Multisite reservation with wrong RR, see next line. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
11	0	1	1	0	0	1	Attempt at multisite reservation with wrong RR. Transponder must not accept reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
12	0	1	1	0	1	0	Multisite reservation, correct. (IIS sensitive: States 2-4 use all 16 IIS codes, State 5 use one incorrect IIS and the correct IIS)
13	1	0	0	0	0	0	Non-selective cancellation. For State 3, run 2 cases, one use RR < 16 with DI≠3 and the second case use RR < 16 and DI=3.
14	1	0	0	0	0	1	Non-selective cancellation and ground initiated Comm-B extraction. For States 3 and 5, specifically run 3 cases, one use RR=16 with DI=3 & RRS≠0, the second case use RR≠16 and DI=3, and third use RR=16 with DI=7, and RRS≠0.

Interrogation Patterns							
#	**A**	**B**	**C**	**D**	**K**	**L**	
15	1	0	0	0	1	0	Non-selective cancellation and attempt to extract possible message still waiting at the air-initiation interface. For States 2, 3 and 4, run 2 cases, one use any interrogation to satisfy condition K with DI≠3 and the second case use RR=16 with DI=3 and RRS=0.
16	1	1	0	0	0	0	Non-selective cancellation, multisite not for Comm-B. (IIS sensitive: State 5 use all 16 IIS codes)
17	1	1	0	0	0	1	Non-selective cancellation with ground initiated Comm-B extraction, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
18	1	1	0	0	1	0	Non-selective cancellation and attempt to extract possible message still waiting at air-initiation interface, multisite not for Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
19	1	1	0	1	0	0	Non-selective cancellation and multisite closeout, cancel non-selective message and close out multisite message if IIS is correct. (IIS sensitive: State 5 use all 16 IIS codes)
20	1	1	0	1	0	1	Non-selective cancellation and multisite close-out and ground-initiated Comm-B extraction. Will cancel non-selective message and will close out multisite message if IIS is correct. Will extract Comm-B. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
21	1	1	0	1	1	0	Same as above, except with air-initiated extraction. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
22	1	1	1	0	0	0	Non-selective cancellation and reservation with wrong RR. Cancel but make no reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
23	1	1	1	0	0	1	Non-selective cancellation and reservation with wrong RR. Cancel but make no reservation. (IIS sensitive: State 5 use one incorrect IIS and the correct IIS)
24	1	1	1	0	1	0	Non-selective cancellation and reservation. Cancel and make reservation. (IIS sensitive: States 5 & 6 use one incorrect IIS and the correct IIS)

A =	PC=4:	Cancellation
B =	DI=1:	Multisite in effect
C =	MBS=1:	Multisite reservation
D =	MBS=2	Multisite closeout
K[2] =	RR=16 with DI ≠ 7 and DI ≠ 3, or with DI=7 or DI=3 and RRS=0[1]	Air initiated MB extraction
L =	RR larger than 15 but not according to code K above	Ground MB extraction

[1] *Use of RR=16 and DI=3 and RRS=0 only when specified in interrogation pattern.*
[2] *Condition **K** also includes conditions **M** and **N**.*

The symbols A, B, C, etc., correspond to the symbols on the flowchart (Figure 2-20).

For IIS sensitive interrogation patterns, use IIS≠0 unless stated in the table.

For State 6, always use the correct IIS code with the exception of interrogation pattern 24, where an incorrect IIS code is also used.

When the IIS code must not equal ZERO (0), or must be incorrect, the value used should be varied with different interrogation patterns.

Interrogation patterns 10, 11, 22, 23 are forbidden to the sensor. They must be used to verify that the transponder makes reservations only when the reservation is accompanied by extraction of the message.

To ‘set the B-bit’, use DR=1 and DR=3 commands alternately during the test sequence.

If PC is not required to be 4, use all other codes. If MBS is not required to be 1 or 2, use codes 0 and 3. If RR is required to be less than 16, use all codes less than 16.

Test Sequence.

All 1435 combinations of the transponder states and interrogation patterns must be used. Additional interrogations may be needed to set transponder states. The test sequence may be set up so that when the transponder enters a given state, all interrogation patterns are used that will not change the state, followed by patterns that will. The test then proceeds with the newly acquired state.

UM Field Verification

During the test sequence when the DI is required to be 1, alternately use RSS=0 and 1, and when DI is not required to be 1, alternately use DI=0 and 7, so that the reply will contain IIS and IDS in the UM field according to §2.2.19.1.9. DI=3 is required for certain interrogation patterns and transponder states in order to verify that attempts to cancel a Comm-B via PC=4 when DI=3 does not incorrectly cancel the message and to verify that interrogations with RR=16, DI=3 and RRS=0 do not set the T register.

These fields are used to verify the Comm-B reservation status and associated IIS as a result of each interrogation pattern and transponder state.

Required Negative Tests

Concurrent tests are part of the sequence above.

Inserted tests must be interspersed within the sequence.

Insert interrogations of formats other than UF=4, 5, 20, 21 and verify that they have no effect on the protocol.

Such interrogations should constitute one percent of the total number of interrogations used.

The interrogation patterns 2 and 14 must include, when RR=16 is used, the combinations of RR=16 with DI=3or7 and RRS Codes 1 through 15. It must be verified that these combinations do not cause the air-initiated Comm-B message to be transmitted.

Additional interrogation sequences are required to verify that SD content is not misinterpreted as Comm-B multisite reservation or cancellation requests when DI is not equal 1. Use the following interrogations using all DI values other than 1 with SD content consistent with the Comm-B multisite reservation or cancellation requests required by interrogation patterns 7 and 12 as if DI were equal to 1:

Interrogation pattern 7 DI≠0 or 7, State 5 (IIS correct) – expected results 5 a,d,e

Interrogation pattern 7 DI=0 and 7, State 5 (IIS correct) – expected results 5 a,d,f

Interrogation pattern 8 DI≠0 or 7, State 5 (IIS correct) – expected results 5 a,d,e,j

Interrogation pattern 8 DI=0 and 7, State 5 (IIS correct) – expected results 5 a,d,f,j

Interrogation pattern 12 DI≠3 or 7, State 2 – expected results 3 b,d,e,j

Interrogation pattern 12 RR=16, DI=3 and RRS=0, State 2 – expected results 2 b,d,e,j

Note: *Interrogation pattern 12 can not be tested with DI=7 since the SD content would contain RRS≠0 when the equivalent bits for MBS=1 (for DI=1) are set.*

Additional interrogation sequences are required to verify that SD content is not misinterpreted as containing an IIS code (when DI≠0, 1 or 7) when a multisite reservation is active and a non-selective cancellation is requested. Use the following interrogations using all DI values other than 0, 1 or 7 with SD content consistent with the correct IIS in bits 17-20 for interrogation patterns 13 and 15:

Interrogation pattern 13 State 5 (IIS correct) – expected results 5 a,d,e

Interrogation pattern 15 State 5 (IIS correct) – expected results 5 b,d,e,j

Timer Duration and Automatic Closeout Test

Arrange the sequence so that the timer runs out occasionally. Verify timer duration and closeout.

Either during the test sequence or in a separate test, verify that interrogation patterns 10, 11, and 12 do not restart the timer when the transponder is in state 5 and the IIS is incorrect. Verify that interrogation patterns 10 and 11 do not restart the timer when the transponder is in state 5 and the IIS is correct. Verify that interrogation pattern 12 does restart the timer when the transponder is in state 5 and the IIS is correct.

Simultaneous Tests

While the transponder is undergoing the verification of the B-protocol, the number of interrogations and replies can be used to make tests for interface action, message content, etc. Such tests are described in Procedures 19 through 23.

Expected Transponder States as a Function of Interrogation Pattern and Prior Transponder State:

Interrogation Pattern	**Transponder State**						
	1	**2**	**3**	**4**	**5 (IIS incorrect)**	**5 (IIS correct)**	**6**
1	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	5 a,d,f	6 a,d,f
2	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	5 b,d,f,i	6 b,d,f,i
3	1 b,c,e,h	3 b,d,e,j or 2 b,d,e,j[3,5]	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	5 b,d,f,j	6 b,d,f,j
4	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	5 a,d,f	6 a,d,f
5	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	5 b,d,f,i	6 b,d,f,i
6	1 b,c,e,h	3 b,d,e,j	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	5 b,d,f,j	6 b,d,f,j
7	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
8	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
9	1 b,c,e,h	3 b,d,e,j	3 b,d,e,j	4 b,d,e,j	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
10	1 a,c,e	2 a,d,e	3 a,d,e	4 a,d,e	5 a,d,f,l	5 a,d,f,l	6 a,d,f
11	1 b,c,e,i	2 b,d,e,i	3 b,d,e,i	4 b,d,e,i	5 b,d,f,i,l	5 b,d,f,i,l	6 b,d,f,i
12	1 b,c,e,h	5 b,d,g,j or	5 b,d,g,j or	6 b,d,g,j or	5 b,d,f,j,l	5 b,d,f,j,m	6 b,d,f,j

		3 b,d,e,j[1]	3 b,d,e,j[1]	4 b,d,e,j[1]			
13	1 a,c,e	2 a,d,e	1 a,c,e or 3 a,d,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
14	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i or 3 b,d,e,i[4]	2 b,d,e,i or 4 b,d,e,i[4]	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
15	1 b,c,e,h	3 b,d,e,j or 2 b,d,e,j[3,5]	1 b,c,e,h or 3 b,d,e,j[3]	3 b,d,e,k or 4 b,d,e,j[3]	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
16	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
17	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
18	1 b,c,e,h	3 b,d,e,j	1 b,c,e,h	3 b,d,e,k	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
19	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
20	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
21	1 b,c,e,h	3 b,d,e,j	1 b,c,e,h	3 b,d,e,k	5 b,d,f,j	1 b,c,e,h	3 b,d,e,k
22	1 a,c,e	2 a,d,e	1 a,c,e	2 a,d,e	5 a,d,f	1 a,c,e	2 a,d,e
23	1 b,c,e,i	2 b,d,e,i	1 b,c,e,i	2 b,d,e,i	5 b,d,f,i	1 b,c,e,i	2 b,d,e,i
24	1 b,c,e,h	5 b,d,g,j	1 b,c,e,h	5 b,d,g,k	5 b,d,f,j	1 b,c,e,h	5 b,d,f,k,m or 6 b,d,f,j,l[2]

[1] If IIS = 0
[2] If IIS is incorrect
[3] If RR=16, DI=3 and RRS=0
[4] If DI=3
[5] Follow with interrogation pattern 13 and verify State 2 result

Verification Required:

a	Short Reply (DF=4, 5)
b	Long Reply (DF=20, 21)
c	DR = 0, No Downlink Request
d	DR = 1 or 3, Request to Send Comm-B
e	UM = No Comm-B reservation or no content
f	UM = IDS = 1, Comm-B Reservation Active, IIS = Value Set with Transponder State
g	UM = IDS = 1, Comm-B Reservation Active, IIS = Value in Interrogation
h	MB = All 0's
i	MB per RR
j	MB Contains 1st Comm-B Message Inserted
k	MB Contains 2nd Comm-B Message Inserted
l	Verify Multisite Timer is not Restarted
m	Verify Multisite Timer is Restarted

2.5.4.18A Procedure #18A Enhanced Comm-B Protocol

If the transponder adheres to the enhanced air-initiated Comm-B protocol as described in §2.2.21.1.2, the following test procedures **shall** verify that the enhanced protocol is carried out correctly by the transponder.

The following tests verify that:

The transponder will properly carry out the Comm-B protocol and will operate with non-selective interrogators, interrogators in multisite configuration and interrogators that will take advantage of the enhanced protocol and extract B messages without making Comm-

B reservations. The modified Comm-B protocol test will verify that the transponder can properly carry out the enhanced Comm-B protocol, handling 16 independent B timers, one for each II and up to 16 concurrent Comm-B messages waiting indications to ground interrogators.

Procedure:

The transponder **shall** be tested according to the guidelines stipulated in procedure 18 with the following additions and/or modifications:

Transponder conditions E and F are defined for non-selective and IIS values 1 - 15. The transponder condition G is defined for IIS values 1 - 15. Condition H is no longer a necessary condition since the transponder can have 15 concurrent reservations.

Procedure 18 is expanded to include additional combinations of conditions E, F and G. For current transponder state 1, produce 15 additional states with a Comm-B message not waiting for II=1 - 15. As the II varies, vary the number of other Comm-B messages waiting for the remaining II values from 0 - 15. States 2 and 3 must be similarly expanded except these states stipulate a Comm-B message waiting as II varies from 0 - 15. The number of Comm-B messages waiting concurrently with the Comm-B message for the II under test is to vary from 0 - 15. It should be noted that state changes from interrogations will be more extensive with the enhanced protocol and that proper setup is required to produce the required transponder states. It is necessary to produce a Comm-B message waiting for the proper IIS by input of directed Comm-Bs to the transponder or a Comm-B message for II of 0 followed by the extraction by the necessary IIS. Verification of proper transponder state requires multiple interrogations to extract the transponder state for each IIS. An air initiated Comm-B message which is extracted by a non zero IIS potentially changes all 16 Comm-B message states. Those interrogation patterns used to close out a Comm-B message for a given IIS must insure that the proper message for the given IIS is closed out. The reply data for Comm-B messages **shall** be verified. Each of the interrogation patterns 1 through 24 inclusive are now IIS sensitive and must be run for each IIS value.

Additionally, verify for each IIS that upon B timer expiration, the message for that IIS is indicated as available to all other available II codes. Repeat the procedures defined above for 2, 3 and 4 segment Comm-Bs and insure that the proper data is indicated in the replies.

UM Field Verification

In all cases, verify that the transponder reports the proper state in the UM field and the report is for the IIS contained in the interrogation pattern.

2.5.4.19 Procedure #19: AIS Flight Identification, Protocol and Interface

The requirements provided in §2.2.19.1.13 establish the baseline reporting and method of encoding Aircraft Identification. Section §2.2.24 addresses Elementary Surveillance requirements which specify detailed implementation requirements for Aircraft Identification. Section §2.6 provides detailed test procedures to validate the requirements of section §2.2.24. Since section §2.6 must address testing of all Aircraft Identification requirements, appropriate procedures to validate the requirements of §2.2.19.1.13 are provided as detailed in the following subparagraphs:

a. Aircraft Identification Reporting (§2.2.19.1.13.a)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.b, §2.6.6.2.b, §2.6.6.3.b, §2.6.6.4.b, §2.6.6.5.b, §2.6.6.6.b, §2.6.6.7.b, §2.6.6.8.b and §2.6.6.8.e.

b. AIS Aircraft Identification Subfield in MB (§2.2.19.1.13.b)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.b, §2.6.6.1.c, §2.6.6.2.b, §2.6.6.3.b, §2.6.6.4.b, §2.6.6.5.b, §2.6.6.6.b, §2.6.6.7.b, §2.6.6.8.b and §2.6.6.8.e.

c. Coding of the AIS Subfield (§2.2.19.1.13.c)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.b, §2.6.6.1.c, §2.6.6.2.b, §2.6.6.3.b, §2.6.6.4.b, §2.6.6.5.b, §2.6.6.6.b, §2.6.6.7.b, §2.6.6.8.b and §2.6.6.8.e.

d. Aircraft Identification Capability Reporting (§2.2.19.1.13.d)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.g, §2.6.6.8.c and §2.6.6.8.f.

e. Change of Aircraft Identification (§2.2.19.1.13.e)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.b, §2.6.6.1.c, §2.6.6.2.b, §2.6.6.2.c, §2.6.6.3.b, §2.6.6.3.c, §2.6.6.4.b, and §2.6.6.4.c.

f. Six-Bit Character Set for Coding Aircraft Identification in the AIS Subfield (§2.2.19.1.13.f)

Appropriate Test Procedures are provided in §2.6.6.1 through §2.6.6.9. Specific subsections include §2.6.6.1.b, §2.6.6.2.b, §2.6.6.3.b, §2.6.6.4.b, §2.6.6.5.b, §2.6.6.6.b, §2.6.6.7.b, §2.6.6.8.b and §2.6.6.8.e.

2.5.4.20 Procedure #20: Extended Capability Report

(§2.2.14.4.21 – BDS)
(§2.2.14.4.35 – RR)
(§2.2.19.1.12.2 – extended data source)
(§2.2.19.1.12.6 through §2.2.19.1.12.6.2 – protocol)
(§2.2.19.1.12.6.3 – updating)
(§2.2.19.1.17 – interface)
(§2.2.22.1.2.2)

This test procedure verifies that the transponder, given the correct interrogation, reports its capability in the MB field of a Comm-B reply. Also verified is the correct functioning of the interface used (if any) and the updating function if it is part of the transponder.

Interface

The source that generates the content of the extended capability report may be internal or external to the transponder. If internal, only the correctness of the report can be verified, if external and not connected to the transponder, the interface action must be verified.

Interface Patterns

The extended capability report occupies the last 48 bits of MB and carries BDS1=1 and BDS2=0, 1; BDS2 codes larger than 1 may also be used.

A total of 2256 interface verification patterns (Procedure #19) must be used if an external report source is used.

Interrogation Patterns

If during the B-protocol test procedure (Procedure #18) an interrogation pattern is used that requires RR to be larger than 16 (Column L), use RR=17 as often as required to carry out the extended capability report verification.

Test Sequence for Internal Report Source

Use RR=17 and, if required, RR=17, DI=7 and RRS=required BDS2 to extract the report.

Verify that the content of the report is correct.

If possible, change the capability and observe that the transponder gives a broadcast Comm-B request. Verify the content of the new report.

2.5.4.21 Procedure #21: Directed Comm-B

(§2.2.19.2.3.2 – protocol)
(§2.2.13.3.2 – interface [see note])

This test procedure verifies that multisite directed Comm-B transmissions are carried out correctly by the transponder.

Transponder Design

The command to the transponder, that an air-initiated Comm-B **shall** be directed to a known sensor, originates in a peripheral device. The transponder must recognize such a command and may be designed to accept it in one of two ways.

One possible design operates as follows: Regardless of the transponder state, the interface inserts a downlink pattern containing DR=1 (the B-bit), IIS (the UM code of the desired destination), and IDS (the UM Comm-B reservation code). Usually, the transponder would pass through the IIS and IDS codes without further examination. For this function, however, both are sensed so that, as soon as the T_{RB} timer is found not to be running, this pattern can be used for a routine surveillance or communication reply. The protocol sequence as tested in Procedure #18 then takes over and completes the transaction cycle.

Another design would provide for a separate dedicated interface which may accept only the desired destination or may be designed to take all of the directed communication.

The interface adapter used in the test setup must conform to the design of the transponder to be tested.

Interface Patterns of Test Sequence

During the B-protocol test procedure (Procedure #18), use the interface pattern as described above or enter into the special interface the patterns necessary to cause a directed Comm-B initiation.

Use IIS codes from 1 to 15 (a total of 15 codes) and reply formats DF=4, 5, 20, 21.

Verify that the pattern transmitted by the transponder corresponds to the pattern inserted. Give special attention to the BDS codes that may have been inserted, depending on transponder design.

Verify that this directed Comm-B has not interrupted another existing reservation condition. If the transponder has implemented the enhanced multisite Comm-B protocol, verify that if an air-initiated message has been extracted by a given non zero IIS and the transponder is currently reserved for the IIS extracting it, that a directed Comm-B message to this IIS is queued and made available subsequent to the closeout of the B message to this IIS.

Verification that this Comm-B has been extracted by the assigned interrogator is intrinsic in Procedure #18 and need not be repeated.

2.5.4.21A Procedure #21A Comm-B Broadcast (§2.2.19.1.12.5 protocol)

Test Procedure:

Notes:

1. *The command to the transponder that a Comm-B broadcast message **shall** be sent originates in a peripheral device or in the device that holds the extended capability report.*
2. *The Comm-B broadcast does not affect the existing Comm-B protocol, air or ground initiated. The existing test procedures remain unchanged.*
3. *Verification of interface patterns is already part of the Comm-B test procedures and need not be repeated for the Comm-B Broadcast.*

This test procedure verifies that the Comm-B broadcast protocol is carried out correctly.

During the B-protocol test procedure (Procedure #18) insert the appropriate DR code command and text of the Comm-B broadcast into the transponder.

Verify that:

1. The transponder does show the DR codes 4, 5, 6, or 7 only when no air-initiated Comm-B transaction is in progress.
2. The Comm-B broadcast message can be extracted by the interrogator for 18 ±1 seconds.
3. The Comm-B broadcast annunciation (DR=4, 5, 6, or 7) and the Comm-B broadcast text are interrupted by an air-initiated Comm-B initiation and reappear when that transaction is concluded. For transponders implementing the enhanced air initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. After the Comm-B is concluded for each II, the Comm-B broadcast is again available to that interrogator. Verify that the next waiting broadcast message is not announced to any interrogators until the current broadcast message has timed out for all interrogators.
4. After interruption another 18 ±1 seconds of broadcast time is available to the interrogator. For transponders implementing the enhanced air-initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. After interruption, another 18 ±1 seconds of broadcast time is available for each II.
5. A subsequent and different Comm-B broadcast message is announced with the alternate DR code and that this DR code also follows verifications 1 through 4 above. For transponders implementing the enhanced air-initiated Comm-B protocol, the transponder will be independently interrupted by up to 16 Comm-B messages that are assigned to each II code. The subsequent Comm-B broadcast is announced only after each Comm-B is broadcast timer has expired for all II codes.

2.5.4.22 Procedure #22: Downlink Interface, Storage Design, Buffer Rate

(§2.2.13.3.2.c – buffer rate)
(§2.2.13.3.2.d – buffer function)
(§2.2.13.3.2.e – unavailable data)
(§2.2.3.4.2 – data rate)

This test procedure verifies that, when a storage design is used for the downlink interface, the buffer functions correctly and that the buffer capacity is sufficient. Transponder action when data are not available is also verified.

Interface Patterns

The buffer must contain at least 16 MB patterns. The 16 MB patterns can have 16 different BDS1 and 16 different BDS2 codes, a total of 256. Several messages (MB patterns) with identical codes can exist for insertion as air-initiated Comm-B.

Air-Initiated Comm-B

The buffer must have space to indicate which of the stored MB patterns are intended for air-initiated Comm-B. It must have means to sequence their insertion in the order received.

Message Output

If the interface circuit used for the AIS and the extended capability reports is also used in this test, message content verification has already been done. It is recommended that differing patterns be used for different BDS codes.

If the interface circuit is not the one already verified, the 2256 test patterns described in Procedure #19 must be used.

Buffer Input Rate

The buffer input rate must be at least 16 MB patterns per second; there is no upper limit, because aircraft data can be updated so that a newly arrived pattern replaces an already stored pattern of the same BDS code.

Test Sequence, Buffer Design

Enter 16 messages into the downlink interface in the following sequence:

a. Five messages with different BDS codes and intended for air-initiated Comm-B.

b. Eight messages with different BDSl codes intended for ground initiation.

c. Two messages with BDS codes identical to the codes intended for air-initiation but with message content differing.

d. One message identical in BDS code but differing in content from the group in b above.

The object of this test sequence is to verify that:

The five air-initiated messages are delivered in the sequence received, and the B-Protocol (Column L of the interrogation patterns listed in Procedure #18) is carried out correctly. The differing BDS codes serve to identify the sequence of the messages.

The 8 ground-initiated messages are extracted by RR corresponding to their BDS1 code in a sequence chosen by the interrogator and that these messages can be extracted several times each.

The buffer has separately stored messages not intended for air-initiation, i.e., the buffer must not replace existing BDS codes if they are intended for air-initiation.

The message in “d” above has replaced (updated) one of the eight ground-initiated messages and that only this message, rather than the previous entry, is transmitted when the interrogator calls for it.

An MB field consisting of ALL ZEROs is transmitted if the interrogation asks for a BDS code not presently in the buffer.

This test sequence fits into the sequence of Procedure #18.

Test Sequence, Buffer Rate and Function

Enter 16 messages with differing BDS (BDS1 and BDS2) codes into the buffer.

In the next three seconds:

a. Interrogate at a rate of 1250/sec (once every 800 microseconds), extracting the messages from the buffer by use of the required RR, DI and RRS codes. Stop interrogating after all messages have been received once.

b. Start entering replacement messages with differing content but identical BDS codes at the rate of at least 16/sec.

c. One second after the start of this sequence (a), start extracting the messages again. Schedule extraction in bursts, each burst consisting of two interrogations following each other 800 microseconds apart. Schedule eight bursts, one after each 125 milliseconds.

d. Two seconds after the start, continue extracting messages at the rate of five/sec.

Verifications:

Test “a” above verifies that the transponder and the buffer can sustain the minimum reply rate as specified.

Tests “b” and “c” are used to verify that messages of like BDS codes are replaced and that in this process no scrambling of messages occurs.

Test “d” verifies that, as messages are updated, they are replaced within the buffer structure regardless of whether they have been transmitted.

This test sequence fits into the sequence of Procedure #18.

2.5.4.23 Procedure #23: Downlink Interface, No-Storage Design

(§2.2.13.1.2.a – insertion)
(§2.2.13.3.2.b – no-storage design)
(§2.2.13.3.2.e – unavailable data)

This test procedure verifies that the no-storage design or "real time" downlink interface performs as specified.

Interface Patterns

This downlink interface operates in real time in conjunction with an uplink interface that also is a no-storage design. Message extraction commands for Comm-B appearing at the uplink interface are recognized by the message source which then enters the downlink content into the downlink interface in time to be transmitted in reply to the interrogation.

For air-initiated Comm-B transactions, the interface can insert the B-bit Code (DR=1) into short and long replies.

For directed Comm-B transmissions (Procedure #21), insertion of IIS and IDS into the UM field is required.

Because the data rate of a real-time interface equals the data rate of the transponder by definition, rate verifications are not necessary.

Test Sequence

If during the B-protocol test procedure (Procedure #18) messages have to be sent or message content has to be verified, supply this interface with the patterns required.

Verify interface design correctness by use of the 2256 test patterns described in Procedure #19.

Verify that B-bit insertion is accepted by the transponder in all applicable formats and that IIS and IDS insertion is accepted by the transponder only if the UM field is not in use for another purpose.

2.5.4.24 Procedure #24: Comm-C Protocol

(§2.2.20.1.1 through §2.2.20.1.1.1.8 – protocol)
(§2.2.20.1.3 through §2.2.20.1.3.5 – multisite)
(§2.2.19.2.1.1 through §2.2.19.2.2.2 – multisite)
(Figure 2-21 and Figure 2-22 – Flowchart)

This test procedure verifies that the Comm-C protocol is carried out correctly.

The test procedure follows the notation of transponder states and of interrogation patterns as shown in the flowcharts.

Transponder States					
#	**H**	**I**	**J**	**K**	
1	0	0	0	0	No ELM action in progress.
2	0	0	1	0	Waiting for segments, not multisite.
3	0	0	1	1	Ready for cancellation by PC=5.
4	1	0	0	0	Multisite reservation made, waiting for RC=0.
5	1	0	1	0	Multisite, waiting for segments.
6	1	0	1	1	Cannot be canceled or closed out.
7	1	1	0	0	Can be canceled or closed out.
8	1	1	1	0	Can be canceled or closed out.
9	1	1	1	1	Ready for cancellation or closeout.

H = T timer running.
I = IIS = stored value.
J = setup active.
K = all segments received.

States 7, 8, 9 are II-sensitive and must be used 16 times. States 3, 6, 9 are sensitive to the number of segments in the ELM, and must be used 15 times.

There are 354 transponder states to be used.

Interrogation Patterns										
#	**B**	**D**	**A**	**C**	**E**	**F**	**M**	**N**	**O**	
1	0	1	0	0	0	0	0	0	0	Ordinary surveillance/ Comm-A.
2	0	1	0	0	0	1	0	0	0	Invalid Closeout: DI is wrong.
3	0	1	0	0	1	0	0	0	0	Invalid Reservation: DI is wrong.
4	0	1	0	1	0	0	0	0	0	DI, but not for Comm-C.
5	0	1	0	1	0	1	0	0	0	Closeout.
6	0	1	0	1	1	0	0	0	0	Reservation.
7	0	1	1	0	0	0	0	0	0	Cancel if not multisite.
8	0	1	1	0	0	1	0	0	0	Cancel if not multisite.
9	0	1	1	0	1	0	0	0	0	Cancel if not multisite.
10	0	1	1	1	0	0	0	0	0	Cancel if not multisite, DI not for Comm-C.
11	0	1	1	1	0	1	0	0	0	Cancel if not multisite and closeout.
12	0	1	1	1	1	0	0	0	0	Cancel if not multisite and reservation.
13	1	0	0	0	0	0	0	0	0	UF=24, not for Comm-C.
14	1	0	0	0	0	0	0	0	1	Segment with TAS request.
15	1	0	0	0	0	0	0	1	0	Segment.
16	1	0	0	0	0	0	1	0	0	Initial Segment.

A = PC=5 = cancel C.
B = UF=24.
C = Dl=1 = multisite code.
D = UF=4, 5, 20, 21.
E = MES=1, 5 = reservation.
F = MES=2, 6, 7 = closeout.
M = RC=0.
N = RC=1.
O = RC=2.

Patterns 5 and 6 must be repeated 16 times for all IIS values.

Patterns 14, 15 and 16 must be repeated 15 times for all valid NC values.

There are 88 interrogation patterns to be used.

<u>Test Sequence</u>

All 31152 combinations of the 354 transponder states and 88 valid interrogation patterns must be used. Interrogate so that the transponder enters a given state and then use all interrogation patterns that will not change the state, followed by patterns that will. Repeat with the now-acquired state. This must be done until all 31152 combinations have been exhausted. Some combinations must be repeated because more than one interrogation pattern can change the state. Extraction of TAS (see flowchart) can be used for verification.

<u>Required Negative Tests</u>

If PC is not required to be 5, use all other codes. If MES is not required to be l, 2, 5, 6, 7, use all other codes.

If RC is not required to be 0, 1, 2, use RC=3.

Insert interrogation formats other than UF=4, 5, 20, 21, 24 one percent of the time to verify that they have no effect on the protocol.

UM Field Verification

During the test sequence when a multisite reservation is made (patterns 6, 12), the following reply will contain IIS and IDS in the UM field according to §2.2.19.2.1.2. Verify that the UM content is correct.

TAS Field Verification

During the test sequence when a TAS report is requested (pattern 14), the reply will contain the TAS field. Verify that the content of TAS is correct.

Timer Duration and Automatic Closeout Test

Arrange the sequence so that the timer runs out occasionally and verify timer duration and closeout.

Simultaneous Tests

While the transponder is undergoing the verification of the C-protocol, the interrogations can also be used to make tests for interface action and message content. These tests are described in Procedure #25.

Enhanced Uplink ELM Protocol

If the enhanced uplink ELM protocol is implemented, the procedure above is modified to reflect the automatic reservation of uplink ELMs. Transponder states 2, 3, 4, 5 and 6 are eliminated. The remaining states 1, 7, 8 and 9 are expanded because of conditions H, J and K varying for each II code. Condition H is expanded to 16 conditions, one for each II code. Condition I is no longer meaningful. Conditions J and K are also expanded to 16, one for each II code. State 1 for II code of 0 is simultaneous with the other 15 II codes varying between states 1, 7, 8 and 9. The number of iterations to run every possible combination is impractical. The test procedure will use different combinations of the additional possible states to provide verification of parallel operations. Interrogation patterns 14, 15 and 16 are further repeated 16 times for all IIS values. The verification procedure will include matching the reported segment data for each II code to that sent in the interrogation. The subset of the expanded states to run are:

1) 16 states, where the conditions are met once for each of the II codes.

2) 15 states, where the conditions are met for II code 0 along with one single II code.

3) 15 states, where the conditions are met for 2 non zero II codes, 3, 4, 5, etc., to 15 parallel non zero II codes and ending with all 16 II codes meeting the conditions.

The conditions for the other II codes not stipulated can be uniformly selected to provide a distribution of concurrent conditions.

The above results in 46 states to test in replacement of state 1, 46 states from state 7, 46 states to replace state 8 and 690 states to replace state 9.

2.5.4.25 Procedure #25: Uplink Interface, ELM-C

(§2.2.13.4 – interface)
(§2.2.20.1.4 – interface rate)

This test procedure verifies that the information contained in Comm-C interrogations passes out of the transponder within the specified time interval and that such information correctly replicates the received transmission content. This test is independent of the interface design.

Interrogation Pattern

UF=24.

MC=6320 different patterns, half containing two ONEs, half containing two ZEROs.

Test Sequence

If during the C-Protocol test procedure (Procedure #24), all segments have been received and are shifted out of the interface (Column K), verify that their content corresponds to the previously inserted patterns.

Verify that the content of four 16 segment ELMs can be extracted from the interface in any four second interval or, in one second if the transponder adheres to the enhanced uplink ELM protocol.

Interrogate with a burst of 16 segments and repeat 4 seconds later, one second later if the transponder adheres to the enhanced uplink ELM protocol.

Verify that the content of the first burst appears at the interface before the second burst is transmitted.

Verify the content of both bursts.

This test fits into the sequence of Procedure #24.

2.5.4.26 Procedure #26: Comm-D Protocol

(§2.2.19.2.1.1 – SD codes)
(§2.2.19.2.1.2 – UM codes)
(§2.2.19.2.2.1 and §2.2.19.2.2.2 – multisite)
(§2.2.20.2.3 through §2.2.20.2.3.6 – multisite)
(§2.2.20.2.1.1 through §2.2.20.2.1.1.5 – ELM-D)
(Figure 2-23 and Figure 2-24 – Flowchart)

This test procedure verifies that the Comm-D protocol is carried out correctly.

The test procedure follows the notation of transponder states and interrogation patterns as shown in the flowcharts.

Transponder States			
#	**E**	**F**	
1	0	0	Not multisite, will accept cancellation or reservation.
2	0	1	Not multisite, will accept cancellation or reservation.
3	1	0	Multisite, will not accept closeout, cancellation, reservation.
4	1	1	Multisite, will accept closeout, cancellation, reservation.

E = T_{RD} timer running.
F = IIS = stored value.
States 3 and 4 are IIS-sensitive and must be used 16 times.

There are 35 transponder states to be used.

Transponder Design

The maximum number of segments that transponders are able to transmit in one burst varies from 4 to 16; the number of tests to be made varies with the burst capability.

Interrogation Patterns

#	H	G	A	B	C	D	I	
1	0	1	0	0	0	0	0	Ordinary interrogation.
2	0	1	0	0	0	1	0	Invalid closeout, DI wrong.
3	0	1	0	0	1	0	0	Invalid reservation, DI wrong.
4	0	1	0	1	0	0	0	Multisite, not for Comm-D.
5	0	1	0	1	0	1	0	Closeout.
6	0	1	0	1	1	0	0	Reservation.
7	0	1	1	0	0	0	0	Cancellation, not multisite.
8	0	1	1	0	0	1	0	Cancellation, not multisite.
9	0	1	1	0	1	0	0	Cancellation, not multisite.
10	0	1	1	1	0	0	0	Cancellation, multisite not for Comm-D.
11	0	1	1	1	0	1	0	Cancellation and possible closeout, multisite.
12	0	1	1	1	1	0	0	Cancellation, not multisite and reservation.
13	1	0	0	0	0	0	0	UF=24, not for Comm-D.
14	1	0	0	0	0	0	1	UF=24, command to transmit segments per SRS.

A = PC=6 cancel D.
B = DI=1 multisite.
C = MES=3, 6 reservation.
D = MES=4, 5, 7 closeout.
G = UF=4, 5, 20, 21.
H = UF=24.
I = RC=3.

Patterns 5, 6, 11, 12, must be used at least 16 times to provide for all II codes.

Pattern 14 must be used as often as necessary to exhaust the SRS and DR codes according to the capability of the transponder.

Verify that cancellation does not occur when the D-register of Figure 2-23 and Figure 2-24 is not set, i.e., when no request for transmission has been complied with yet.

Test Sequence

The number of combinations of transponder states and interrogation patterns is design dependent. All combinations must be exercised.

DR Verification

At the Comm-B downlink interface, apply a request for air-initiated Comm-B (DR=1), and at the Comm-D interface apply a request to send a Comm-D ELM (DR larger than 15).

Verify that Comm-B has priority by observing that the B-protocol must be closed out before the DR code of the Comm-D transaction appears in replies.

Verify that the DR field in DF=4, 5, 20, 21 correctly states the number of segments waiting at the interface to be transmitted.

UM Verification

If a multisite reservation is made during the test sequence (patterns 6, 12), the following reply will contain IIS and IDS in the UM field according to §2.2.19.2.1.2. Verify that the UM content is correct.

SRS Verification

Consider the SRS bit pattern as a code of length corresponding to the maximum burst capability of the transponder. Use all combinations containing two ONEs and all combinations containing two ZEROs for this word length as the test pattern for the following verifications.

Verify that the transponder correctly transmits the number and identity of segments requested in the SRS subfield of UF=24 with RC=3.

The identity of segments is indicated in the ND field of each segment and must be inserted at the ELM downlink interface.

Verify that if SRS requests a segment identity which is not available in this transaction, the transponder will send ND according to the request but will leave the MD field of that reply all ZEROs.

Required Negative Tests

If PC is not required to be 6, use all other codes. If DI is not required to be 1, use all other codes. If MES is not required to be 3, 4, 5, 6, 7 use all other codes.

Insert interrogation formats other than UF=4, 5, 20, 21, 24 one percent of the time to verify that they have no effect on the protocol.

Timer Duration and Automatic Closeout Test

Arrange the sequence so that the timer runs out occasionally and verify timer duration and closeout.

Simultaneous Tests

While the transponder is undergoing the verification of the D-Protocol, the number of interrogations can be used to make tests for interface action and message content. These tests are described in Procedures #27 and #28.

Enhanced Downlink ELM Protocol

If the transponder adheres to the enhanced multisite downlink ELM protocol as described in §2.2.21.3, the following test procedures **shall** verify that the enhanced protocol is carried out correctly by the transponder.

The transponder **shall** be tested according to the guidelines stipulated above with the following additions and/or modifications:

Transponder condition E is defined for non-selective and IIS values 1 - 15. The transponder condition F is no longer meaningful.

The test will be expanded to include the additional combinations of condition E since the condition exists for each II. The resulting transponder states consist of all combinations of conditions for each of the 16 II codes.

UM Verification

In all cases, verify that the transponder reports the proper state in the UM field and the report is for the IIS contained in the interrogation pattern.

DR Verification

Verify the DR code as described with the addition of DR code extraction for all IIS codes and under the conditions of concurrent B messages, B broadcast messages and downlink ELMs.

2.5.4.27 Procedure #27: Directed Comm-D

(§2.2.20.2.3.2 – protocol)

This test procedure verifies that multisite directed Comm-D transactions are carried out correctly by the transponder.

The comments on transponder design dependence of this test are essentially the same as presented in Procedure #21.

Interface Patterns of Test Sequence

During the D-protocol test procedure (Procedure #26) enter into the interface a downlink pattern containing DR corresponding to the number of segments to be transmitted, IDS=3 (the UM code for Comm-D reservation) and IIS corresponding to the desired destination's code.

Use all IIS codes from 1 to 15 and interrogate so that the downlink formats DF=4, 5, 20, 21 are used.

Verify that this directed Comm-D has not interrupted an existing reservation condition.

Reply and coding content are verified as part of Procedures #26 and #28 respectively.

2.5.4.28 Procedure #28: Comm-D Interface, Rate and Content

(§2.2.13.4 – interface)
(§2.2.20.2.4 – data rate)

This test procedure verifies that the downlink interface can sustain the required data rate and that the transponder transmits downlink content as entered.

Transponder Design

The Comm-D interface can exist as a separate port or as one direction of a bidirectional ELM (C/D) interface. The downlink port can be designed to take the ND and MD fields only, leaving the UF and KE generation to internal circuitry. Another design would need input for DF and KE as well.

The minimum input data rate for this interface must equal the maximum reply capability of the transponder. The maximum practical reply capability is 16 segments in four seconds, although that is not specified in this document.

Interface Patterns

For each ND code appropriate for the transponder under test, generate a total of 6320 MD patterns, half containing two ONEs and half containing two ZEROs.

Test Sequence

Use all required MD patterns and all ND patterns possible for this transponder.

Verify that the patterns are transmitted as entered.

Schedule Comm-D transactions at the maximum rate for which the transponder is designed (4 to 16 segment DELMs at a rate of one per 4 seconds for a standard DELM transponder, 16 segment DELMs at a rate of one per second for an enhanced DELM transponder).

Verify that the interface can supply new MD patterns at those rates.

Note: *It may be necessary to schedule more Comm-D transactions than are required for the protocol test alone.*

2.5.4.29 Not Used

2.5.4.30 Procedure #30: Sensitivity Level Operation (§2.2.22.1.1 and §2.2.22.1.5)

This test verifies that the transponder (1) accepts incoming UF=20, 21 interrogations containing a Sensitivity Level Command Message and passes all necessary information (IIS and SLC subfields) to the TCAS unit, and (2) receives sensitivity level information from the TCAS unit and correctly reports this information in outgoing DF=0, 16 replies.

a. Send a status = "on-board TCAS with vertical-only resolution capability" and a sensitivity level=6 to the transponder via the transponder/TCAS interface.

   Interrogate the transponder with a UF=0 and a UF=16 non-acquisition interrogation.

   Show that the transponder correctly reports the TCAS status and sensitivity level in the RI and SL fields respectively.

b. Interrogate the transponder with a UF=20 interrogation containing a Sensitivity Level Command Message (ADS1=0, ADS2=5, and TMS=0) with IIS=1 and SLC=4.

   Show that the IIS and SLC subfields are correctly output on the transponder/TCAS interface.

c. Interrogate the transponder with a UF=21 interrogation containing a Sensitivity Level Command Message with IIS=15 and SLC=5.

   Show that the IIS and SLC subfields are correctly output on the transponder/TCAS interface.

d. Send a sensitivity level=4 to the transponder via the transponder/TCAS interface. Interrogate the transponder with a UF=0 and a UF=16 non-acquisition interrogation.

   Show that the transponder correctly reports the TCAS status and sensitivity level in the RI and SL fields respectively.

2.5.4.31 Procedure #31: Transmission of RA Report to Mode S Sensor (§2.2.22.h and §2.2.22.1.2.1)

This test verifies that the transponder correctly determines the transponder/TCAS system capability (either FAA TSO-C119a or RTCA/DO-185A/B compatibility) based on communication with the on-board TCAS unit and then reports RA information in the appropriate format. This test requires that the transponder demonstrate proper operation with both FAA TSO-C119a and RTCA/DO-185A/B compatible transponder/TCAS interfaces.

This test verifies that the transponder correctly (1) receives RA information from the TCAS unit, (2) indicates to the ground (DR field in DF=4, 5, 20, and 21 replies) that it has information awaiting downlink, (3) transmits this information in DF=20, 21 replies, (4) retains RA information for 18 ±1 seconds following the end of the RA, and (5) (for RTCA/DO-185A/B compatible transponder/TCAS systems) properly indicates the end of the RA via the RA Terminated indicator.

Note: *The tests refer to a "TCAS bit" in the DR field of DF=4, 5, 20, and 21 replies. The TCAS bit is interpreted herein as bit 12 of the 5-bit (bits 9 – 13) DR field. That is, if DR=2, 3, 6, or 7, then the "TCAS bit" is set, and the transponder is therefore indicating that it has TCAS information available.*

2.5.4.31.1 Procedure #31: Transmission of RA Report for a Transponder Operating with an FAA TSO-C119a Compatible TCAS (§2.2.22.h, §2.2.22.1.2.1, §2.2.22.1.2.1.1, and §2.2.22.1.2.1.2)

a. ARA=0 and RAC=0:

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations when no RA information has been received via the transponder/TCAS interface.

Show that the TCAS bit in the DR field is not set in the DF=4, 5, 20, and 21 replies.

b. ARA≠0 and RAC≠0:

Send ARA='10000000000000' and RAC='1000' to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the 'TCAS bit' in the DR field is set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the TCAS bit in the DR field is set in the DF=20 and 21 replies. Show that the ARA and RAC information is correctly reported in the DF=20 and 21 replies.

Send ARA=0 and RAC=0 to the transponder via the transponder/TCAS interface.

Interrogate the transponder once per second for the next 20 seconds with a UF=4 interrogation with RR=19.

Show that for 18 ±1 seconds after the end of the RA, the TCAS bit in the DR field in the reply remains set and that ARA=1000000000000 and RAC=1000 are reported. Show that after 18 ±1 seconds, the TCAS bit in the DR field in the reply is not set and that ARA=0 and RAC=0 are reported.

c. ARA≠0 and RAC=0:

Repeat all portions of step b replacing every instance of RAC=1000 with RAC=0.

d. ARA=0 and RAC≠0:

Send ARA=0 and RAC='1000' to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the TCAS bit in the DR field is not set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the 'TCAS bit' in the DR field is not set in the DF=20 and 21 replies.

Send ARA=0 and RAC=0 to the transponder via the transponder/TCAS interface.

Interrogate the transponder once per second for the next 20 seconds with a UF=4 interrogation with RR=19.

Show that the TCAS bit in the DR field in the replies is not set.

e. ARA≠0, RAC≠0, new ARA and RAC values received during 18-second time-out:

Send ARA='00000100000000' and RAC='0100' to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the TCAS bit in the DR field is set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the TCAS bit in the DR field is set in the DF=20 and 21 replies. Show that the ARA and RAC information is correctly reported in the DF=20 and 21 replies.

Send the following sequence (60 seconds total) of ARA and RAC data to the transponder via the transponder/TCAS interface.

For 5 seconds, ARA=0 and RAC=0;

For the next 5 seconds, ARA='10000000000000' and RAC='1000';

For the next 5 seconds, ARA='01000000000000' and RAC=0;

For the next 5 seconds, ARA=0 and RAC=0;

For the next 5 seconds, ARA=0 and RAC='0100';

For the next 5 seconds, ARA='01000000000000' and RAC=0;

For the next 30 seconds, ARA=0 and RAC=0.

Interrogate the transponder once per second during the 60 seconds described above with UF=4 interrogations with RR=19.

Show that the TCAS bit in the DR field in the replies remains set for the first 48 ±1 seconds and is set to ZERO thereafter. Show that in the replies:

For the first 5 seconds, ARA='00000100000000' and RAC='0100';

For the next 5 seconds, ARA='10000000000000' and RAC='1000';

For the next 38 ±1 seconds, ARA='01000000000000' and RAC=0;

For the next 12 ±1 seconds, ARA=0 and RAC=0.

2.5.4.31.2 Procedure #31: Transmission of RA Report for a Transponder Operating with an RTCA/DO-185A/B Compatible TCAS (§2.2.22.h, §2.2.22.1.2.1, §2.2.22.1.2.1.1, and §2.2.22.1.2.1.3)

a. ARA=0 and RAC=0:

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations when no RA information has been received via the transponder/TCAS interface.

Show that the ‘TCAS bit’ in the DR field is not set in the DF=4, 5, 20, and 21 replies.

b. ARA≠0 and RAC≠0:

Send ARA=‘10000000000000’, RAC=‘1000’, RAI=0, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX} to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the ‘TCAS bit’ in the DR field is set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the ‘TCAS bit’ in the DR field is set in the DF=20 and 21 replies.

Show that the ARA, RAC, RAT(=0), MTE, TTI, and TID are correctly reported in the DF=20 and 21 replies.

Send ARA=0, RAC=0, RAI=1, and MTE=0 to the transponder via the transponder/TCAS interface.

Interrogate the transponder once per second for the next 20 seconds with a UF=4 interrogation with RR=19.

Show that for 18 ±1 seconds after the end of the RA, the ‘TCAS bit’ in the DR field in the reply remains set, and that RAT=1, ARA=‘10000000000000’, RAC=‘1000’, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX} are reported. Show that after 18 ±1 seconds, the ‘TCAS bit’ in the DR field in the reply is not set and that RAT, ARA, RAC, MTE, TTI, and TID are all set to ZERO.

c. ARA≠0 and RAC=0:

Repeat all portions of step b replacing every instance of RAC=‘1000’ with RAC=0, and replacing TTI=1, TID=‘AAAAAA’ {HEX} with TTI=2, TIDA=‘0101010101010’, TIDR=‘1010101’, TIDB=‘010101’.

d. ARA=0 and RAC≠0:

Send ARA=0, RAC=‘1000’, RAI=1, and MTE=0 to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the ‘TCAS bit’ in the DR field is not set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the ‘TCAS bit’ in the DR field is not set in the DF=20 and 21 replies.

Send ARA=0, RAC=0, RAI=1, and MTE=0 to the transponder via the transponder/TCAS interface.

Interrogate the transponder once per second for the next 20 seconds with a UF=4 interrogation with RR=19.

Show that the ‘TCAS bit’ in the DR field in the replies is not set.

e. ARA≠0, RAC≠0, new ARA and RAC values received during 18-second time-out:

Send ARA=‘00000100000000’, RAC=‘0100’, RAI=0, MTE=0, TTI=1, and TID=‘555555’ {HEX} to the transponder via the transponder/TCAS interface.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations.

Show that the ‘TCAS bit’ in the DR field is set in the DF=4, 5, 20, and 21 replies.

Interrogate the transponder with UF=4, 5, 20, and 21 interrogations with RR=19.

Show that the ‘TCAS bit’ in the DR field is set in the DF=20 and 21 replies. Show that the ARA, RAC, RAT(=0), MTE, TTI, and TID are correctly reported in the DF=20 and 21 replies.

Send the following sequence (60 seconds total) of ARA and RAC data to the transponder via the transponder/TCAS interface.

For 5 seconds, ARA=0, RAC=0, RAI=1, MTE=0;

For the next 5 seconds, ARA=‘10000000000000’, RAC=‘1000’, RAI=0, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX};

For the next 5 seconds, ARA=‘01000000000000’, RAC=0, RAI=0, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 5 seconds, ARA=0, RAC=0, RAI=1, and MTE=0;

For the next 5 seconds, ARA=0, RAC=‘0100’, RAI=1, and MTE=0;

For the next 5 seconds, ARA=‘01000000000000’, RAC=0, RAI=0, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 30 seconds, ARA=0, RAC=0, RAI=1, and MTE=0. Interrogate the transponder once per second during the 60 seconds described above with UF=4 interrogations with RR=19.

Show that the ‘TCAS bit’ in the DR field in the replies remains set for the first 48 ±1 seconds and is set to ZERO thereafter. Show that in the replies:

For the first 5 seconds, ARA=‘00000100000000’, RAC=‘0100’, RAT=1, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 5 seconds, ARA=‘10000000000000’, RAC=‘1000’, RAT=0, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX};

For the next 5 seconds, ARA=‘01000000000000’, RAC=0, RAT=0, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 10 seconds, ARA=‘01000000000000’, RAC=0, RAT=1, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 5 seconds, ARA=‘01000000000000’, RAC=0, RAT=0, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 18 ±1 seconds, ARA=‘01000000000000’, RAC=0, RAT=1, MTE=0, TTI=1, and TID=‘555555’ {HEX};

For the next 12 ±1 seconds, ARA=0, RAC=0, RAT=0, and MTE=0.

2.5.4.32 Procedure #32: Transmission of TCAS Capability Information to a Mode S Sensor (§2.2.22.h and §2.2.22.1.2.2) and to other TCAS Aircraft (§2.2.22.1.5)

This test verifies that the transponder receives operational information from its associated TCAS unit and correctly reports this information in Data Link Capability Reports to a Mode S sensor and in special surveillance replies to another TCAS aircraft. This test requires that the transponder demonstrate proper operation with both FAA TSO-C119a and RTCA/DO-185A compatible transponder/TCAS interfaces.

2.5.4.32.1 Procedure #32: Transmission of TCAS Capability Information to a Mode S Sensor (§2.2.22.h, §2.2.22.1.2.2, §2.2.22.1.2.2.1, and §2.2.22.1.2.2.2) and to other TCAS Aircraft (§2.2.22.1.5) for a Transponder Operating with an FAA TSO-C119a Compatible TCAS

a. Enable the transponder only (i.e., establish the state where the transponder/TCAS interface is not operational).

b. Interrogate the transponder with a non-acquisition UF=0 interrogation.

   Show that the transponder replies with the correct capability information in the DF=0 reply (i.e., RI=0).

c. Interrogate the transponder with the following four interrogations:

   UF=4 with RR=17 and DI≠7;

   UF=5 with RR=17 and DI≠7;

   UF=20 with RR=17, DI=7, and RRS=0;

   UF=21 with RR=17, DI=7, and RRS=0.

   Show, in each of the four cases, that the transponder replies with the correct capability information in the DF=20, 21 replies (i.e., BDS1=1, BDS2=0, bit 48=0, and bits 69, 70, 71, and 72 = 0000).

d. Repeat the procedures in steps b and c above for each of the following 16 cases:

   (1) TCAS reports “on-board TCAS with resolution capability inhibited” (RI=2) to the transponder via the transponder/TCAS interface.

   Show that the transponder replies with RI=2 in the DF=0 reply.

   Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘0000’ in the DF=20, 21 replies.

   (2) TCAS reports “on-board TCAS with vertical-only resolution capability” (RI=3) to the transponder via the transponder/TCAS interface.

   Show that the transponder replies with RI=3 in the DF=0 reply.

   Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘0100’ in the DF=20, 21 replies.

   (3) TCAS reports “on-board TCAS with vertical and horizontal resolution capability” (RI=4) to the transponder via the transponder/TCAS interface.

   Show that the transponder replies with RI=4 in the DF=0 reply.

Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘1000’ in the DF=20, 21 replies.

(4)-(16) TCAS reports RI=0, 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 to the transponder via the transponder/TCAS interface.

Show that for each case, the transponder replies with RI=0 in the DF=0 reply.

Show that for each case, the transponder replies with bit 48=0 and bits 69, 70, 71, and 72 = ‘0000’ in the DF=20, 21 replies.

2.5.4.32.2 Procedure #32: Transmission of TCAS Capability Information to a Mode S Sensor (§2.2.22.h, §2.2.22.1.2.2, §2.2.22.1.2.2.1, and §2.2.22.1.2.2.3) and to other TCAS Aircraft (§2.2.22.1.5) for a Transponder Operating with an RTCA/DO-185A Compatible TCAS

Repeat the procedures provided in Steps “a” through “d” of §2.5.4.32.1 for an RTCA/DO-185A compatible transponder/TCAS interface.

Show that the transponder properly reports with the RI field in DF=0 replies set exactly as provided in Steps “a” through “d” of §2.5.4.32.1.

Show that the transponder properly reports with DF=20, 21 replies that are exactly the same as those specified in Steps “b” through “d” of §2.5.4.32.1 with the exception that bits 70 and 71=0 for the four cases in Step “c” and bit 71=1 for cases 1 – 3.

2.5.4.32.3 Procedure #32: Transmission of TCAS Capability Information to a Mode S Sensor (§2.2.22.h, §2.2.22.1.2.2, §2.2.22.1.2.2.1, and §2.2.22.1.2.2.3) and to other TCAS Aircraft (§2.2.22.1.5) for a Transponder Operating with an RTCA/DO-185B Compatible TCAS

a. Repeat the procedure provided in Step “a” of §2.5.4.32.1 for an RTCA/DO-185B compatible transponder/TCAS interface.

b. Repeat the procedure provided in Step “b” of §2.5.4.32.1 for an RTCA/DO-185B compatible transponder/TCAS interface.

c. Repeat the procedure provided in Step “c” of §2.5.4.32.1 for an RTCA/DO-185B compatible transponder/TCAS interface.

d. Repeat the procedures in steps “b” and “c” above for each of the following 16 cases:

(1) TCAS reports “on-board TCAS with resolution capability inhibited” (RI=2) to the transponder via the transponder/TCAS interface.

TCAS reports that there is no “Hybrid Surveillance” capability to the transponder via the transponder/TCAS interface.

Show that the transponder replies with RI=2 in the DF=0 reply.

Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘0001’ in the DF=20, 21 replies.

(2) TCAS reports “on-board TCAS with vertical-only resolution capability” (RI=3) to the transponder via the transponder/TCAS interface.

TCAS reports that there is “Hybrid Surveillance” capability to the transponder via the transponder/TCAS interface.

Show that the transponder replies with RI=3 in the DF=0 reply.

Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘1101’ in the DF=20, 21 replies.

(3) TCAS reports “on-board TCAS with vertical-only resolution capability” (RI=3) to the transponder via the transponder/TCAS interface.

TCAS reports that there is no “Hybrid Surveillance” capability to the transponder via the transponder/TCAS interface.

Show that the transponder replies with RI=3 in the DF=0 reply.

Show that the transponder replies with bit 48=1 and bits 69, 70, 71, and 72=‘0101’ in the DF=20, 21 replies.

(4)-(16) TCAS reports RI=0, 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15 to the transponder via the transponder/TCAS interface.

Show that for each case, the transponder replies with RI=0 in the DF=0 reply.

Show that for each case, the transponder replies with bit 48=0 and bits 69, 70, 71, and 72=‘0000’ in the DF=20, 21 replies.

2.5.4.33 Procedure #33: TCAS or transponder/TCAS Interface Failure During Transmission of RA Report and Data Link Capability Report to a Mode S Sensor (§2.2.22.1.2.1.3 and §2.2.22.1.2.2.3)

This test applies to RTCA/DO-185A/B compatible systems.

a. Send ARA=‘10000000000000’, RAC=‘1000’, RAI=0, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX} to the transponder via the transponder/TCAS interface once per second for 5 seconds.

During the 5th second, cause the TCAS unit to report a TCAS failure to the transponder (i.e., RI=0 and SL 1).

Interrogate the transponder once per second during the 5 seconds described above and for an additional 25 seconds (30 seconds total) with UF=4 interrogations with RR=19 and DI 7.

Show that in the DF=20 replies:

For the first 23 ±1 seconds, the ‘TCAS bit’ is set in the DR field. Thereafter, it is cleared.

For the first 5 seconds, ARA=‘10000000000000’, RAC=‘1000’, RAT=0, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX}.

For the next 18 ±1 seconds, ARA=‘10000000000000’, RAC=‘1000’, RAT=1, MTE=0, TTI=1, and TID=‘AAAAAA’ {HEX}.

For the remaining 7 ±1 seconds, ARA, RAC, MTE, TTI, and TID all = 0.

b. Repeat the steps in test a, except during the 5th second, cause the transponder to recognize a failure on the transponder/TCAS interface (i.e., disconnect or otherwise interrupt the interface). The results should be the same as in test a.

c. Send “on-board TCAS with vertical-only resolution capability” (RI=3) to the transponder via the transponder/TCAS interface for 5 seconds.

During the 5th second, cause the transponder to recognize a failure on the transponder/TCAS interface (i.e., disconnect or otherwise interrupt the interface).

Interrogate the transponder once per second for 30 seconds with UF=4 interrogations with RR=17 and DI 7.

Show that in the DF=20 replies:

For the first 5 seconds, bit 48=1, and bits 69, 70, 71, and 72='0110'.

For the next 25 seconds, bits 48, 69, 70, 71, and 72 all = 0.

2.5.4.34 Procedure #34: Coordination (§2.2.22.1.3 and §2.2.22.1.4)

This test verifies that the transponder (1) accepts incoming UF=16 interrogations containing a TCAS Resolution Message and passes all necessary information to the TCAS unit, and (2) receives coordination information from the TCAS unit and correctly reports this information in outgoing DF=16 replies. This test requires that the transponder demonstrate proper operation with both FAA TSO-C119a and RTCA/DO-185A/B compatible transponder/TCAS interfaces.

2.5.4.34.1 Procedure #34: Coordination (§2.2.22.1.3 and §2.2.22.1.4.1) for a Transponder Operating with an FAA TSO-C119a Compatible TCAS

a. Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=2, CHC=0, HRC=0, VSB=7 when no resolution advisory information has been received from the TCAS unit.

Show that the transponder sends a DF=16 reply with VDS=48, ARA=0, and RAC=0.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

b. Send ARA=0 and RAC='0100' to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=2, CHC=0, HRC=0, VSB=7.

Show that the transponder sends a DF=16 reply with VDS=48.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

c. Send ARA='00000100000000' and RAC='0100' to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=2, VRC=0, CHC=0, HRC=0, VSB=13.

Show that the transponder sends a DF=16 reply with VDS=48, ARA='00000100000000', and RAC='0100'.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

d. Send ARA='00000100000000' and RAC=0 to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=2, VRC=0, CHC=0, HRC=0, VSB=13.

Show that the transponder sends a DF=16 reply with VDS=48.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

e. Send ARA=0 and RAC=0 to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=1, CHC=0, HRC=0, VSB=14.

Show that the transponder sends a DF=16 reply with VDS=48, ARA=0, and RAC=0.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

2.5.4.34.2 Procedure #34: Coordination (§2.2.22.1.3 and §2.2.22.1.4.2) for a Transponder Operating with an RTCA/DO-185A/B Compatible TCAS

a. Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=2, CHC=0, HRC=0, VSB=7 when no resolution advisory information has been received from the TCAS unit.

Show that the transponder sends a DF=16 reply with VDS=48, ARA=0, RAC=0, RAT=0, and MTE=0.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

b. Send ARA=0, RAC='0100', RAI=1, and MTE=0 to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=2, CHC=0, HRC=0, VSB=7.

Show that the transponder sends a DF=16 reply with VDS=48.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

c. Send ARA='11100000000000', RAC='0100', RAI=0, and MTE=0 to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=2, VRC=0, CHC=0, HRC=0, VSB=13.

Show that the transponder sends a DF=16 reply with VDS=48, ARA='11100000000000', RAC='0100', RAT=0, and MTE=0.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

d. Send ARA='11100000000000', RAC=0, RAI=0, and MTE=1 to the transponder from the TCAS unit.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=2, VRC=0, CHC=0, HRC=0, VSB=13.

Show that the transponder sends a DF=16 reply with VDS=48, ARA='11100000000000', RAC=0, RAT=0, and MTE=1.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

e. Send ARA=0, RAC=0, RAI=1, MTE=0 to the transponder from the TCAS unit. This RAI=1 is intended to represent the transition from RAI=0 to RAI=1 indicating the end of ARA='11100000000000' in d, above.

Interrogate the transponder with a UF=16 interrogation with UDS=48, MTB=0, CVC=0, VRC=1, CHC=0, HRC=0, VSB=14.

Show that the transponder sends a DF=16 reply with VDS=48.

Show that the coordination information in the MU field is correctly output on the transponder/TCAS interface.

2.5.4.35 Procedure #35: MU Messages To TCAS (§2.2.22.1.3)

This test verifies that the transponder correctly:

1) accepts UF=16 interrogations with MU data containing a TCAS Resolution Message (UDS=48) and passes all necessary information to the TCAS unit;

2) accepts UF=16 broadcast interrogations with MU data containing a TCAS Broadcast Message (UDS=50) and passes all necessary information to the TCAS unit; and

3) does not transfer the MU data of UF=16 discrete interrogations with UDS≠48 and broadcast interrogations with UDS≠50 to the TCAS unit.

a. Interrogate the transponder with a valid UF=16 TCAS Coordination Message (UDS1=3, UDS2=0). Verify that the transponder replies with a valid DF=16 Coordination Reply Message and the data content of the MU field is correctly output on the transponder/TCAS interface.

b. In one second, interrogate the transponder with ten UF=16 interrogations, each containing a TCAS Broadcast Message (UDS1=3, UDS2=2, and interrogation address all ONEs), each containing a unique “own” Mode S address (i.e., ten different Mode S addresses). Verify that the MU data for each interrogation is correctly output on the transponder/TCAS interface.

c. Interrogate the transponder at the rate of 10 per second or less with 255 UF=16 interrogations addressed to the transponder with UDS values from 0 to 255 except for UDS=48. Verify that the transponder does not output the messages over the transponder/TCAS interface.

d. Interrogate the transponder at the rate of 10 per second or less with 255 UF=16 broadcast interrogations with UDS values from 0 to 255 except for UDS=50. Verify that the transponder does not output the messages over the transponder/TCAS interface.

2.5.4.36 Procedure #36: Transponder Replies to Incoming TCAS Resolution Messages (§2.2.22.2.1)

This test verifies that:

1) whenever the transponder replies with a valid Coordination Reply Message to an incoming TCAS Resolution Message, the incoming message is successfully delivered to the TCAS unit; and

2) whenever the transponder's internal queue is full or some other condition is present which would prevent delivery of the message to TCAS, the transponder does not reply with a valid Coordination Reply Message to an incoming TCAS Resolution Message and does not pass the incoming data to TCAS.

   a. Interrogate the transponder with a UF=16 interrogation containing a valid TCAS Resolution Message when all of the following conditions are true: the transponder is reporting that it has an operational TCAS; no transponder queues are full; and no TCAS failure conditions exist.

      Demonstrate that the transponder transmits a valid Coordination Reply Message and that the incoming coordination information is correctly output on the transponder/TCAS interface.

   b. Interrogate the transponder with a UF=16 interrogation containing a valid TCAS Resolution Message when the transponder queue is full. Demonstrate that the transponder does not send a valid Coordination Reply Message and does not output the incoming coordination information on the transponder/TCAS interface.

      Demonstrate that when the queue is full the transponder still replies to interrogations that do not contain information directed to the transponder/TCAS interface.

   c. Interrogate the transponder with a UF=16 interrogation containing a valid TCAS Resolution Message when a TCAS failure condition is present (the transponder is reporting no resolution advisory capability).

      Demonstrate that the transponder does not send a valid Coordination Reply Message and does not output the incoming coordination information on the transponder/TCAS interface.

      Demonstrate that when a TCAS failure is present the transponder still replies to interrogations that do not contain information directed to the transponder/TCAS interface.

      Note: *When the transponder does not send a valid reply, it may either send no reply or send a DF=16 interrogation with all 56 bits of the MV field equal to ZERO.*

2.5.4.37 Procedure #37: Transponder/TCAS Throughput (§2.2.22 b and g)

This test verifies that the interrogation input rate requirement and the reply rate limiting requirement referenced above are met by the transponder. In addition, this test is important for demonstrating that the transponder's internal structures (e.g., queues, timing) have been designed in such a way that they are compatible with any TCAS unit with which the transponder is paired.

a. Interrogate the transponder with UF=16 interrogations for 5 seconds at a continuous rate of 16.6 milliseconds, i.e., 60 interrogations per second.

Demonstrate that the transponder accepts all interrogations, transmits a valid reply to each interrogation, and correctly outputs the information on the transponder/TCAS interface in the order that it was received by the transponder.

b. Interrogate the transponder with UF=16 interrogations for 5 seconds at a rate greater than that at which the transponder can accept all interrogations.

Note: *In some installations, interrogating at a high rate with all UF=16 interrogations causes the transponder's internal queue to fill, thus stopping the transponder's acceptance of and reply to interrogations because of the full queue, rather than because of the reply rate limiting. If this is the case, it is necessary to interrogate the transponder with a mix of short and long interrogations; this mix should include the largest number of UF=16 interrogations that is possible while at the same time avoiding any queue overflow. This will allow the reply rate limiting feature to be tested.*

Demonstrate that the reply rate limiting feature is exercised (i.e., there is a mechanism which recognizes the high interrogation rate and stops the transponder from accepting and replying to replies before the transponder overheats or otherwise becomes adversely affected).

Demonstrate that the transponder can accept and reply to at least the number of interrogations specified in §2.2.13.3.1.c.

Demonstrate that for each accepted interrogation, and only for each accepted interrogation, the transponder transmits a valid reply and correctly outputs the information on the transponder/TCAS interface in the order that it was received by the transponder.

c. Interrogate the transponder with UF=16 interrogations at a burst rate greater than that which the transponder can accept. Maintain the burst scenario for at least 5 seconds.

Note: *Burst interrogations must be used to insure that the TCAS interface has not failed because of lack of periodic data updates.*

Cause the TCAS test unit to accept information from the transponder at the slowest rate possible including a retry while still conforming to the transponder/TCAS interface protocols.

Demonstrate that for each accepted interrogation, and only for each accepted interrogation, the transponder transmits a valid reply and correctly outputs the information on the transponder/TCAS interface in the order that it was received by the transponder.

2.5.4.38 Procedure #38: Transponder Communication Timing (§2.2.22.2.4)

This test verifies that the communications timing requirement specified in §2.2.22.2.4 is met.

a. Demonstrate that the elapsed time from the transponder's receipt of an incoming UF=16 interrogation containing a TCAS Resolution Message to the receipt by the TCAS test unit from the TCAS/transponder interface is less than or equal to 0.01 second.

Note: *This assumes an interrogation rate less than or equal to 60 interrogations per second.*

2.5.4.39 Procedure #39: TCAS Crosslink (§2.2.14.4.14, §2.2.14.4.7, and §2.2.18.2.10)

This test verifies that the transponder:

1) correctly reports the Crosslink Capability (CC) in DF=0 replies, and

2) decodes the DS field in UF=0 interrogations and correctly responds with the contents of the ground initiated Comm-B register in the MV field of the corresponding DF=16 reply.

   a. Interrogate the transponder with UF=0, RL=0 interrogations. Verify that the CC field (bit 7) is a one in each DF=0 reply requested.

   b. Generate data for each defined ground-initiated Comm-B message for each of the Comm-B registers that can be controlled via an interface or are internal to the transponder. The data content for each register should be unique so that it can be distinguished from all others. Interrogate the transponder with UF=0, RL=1, and all combinations of DS (1-255). Verify that the contents of the MV field of each DF=16 reply (whose register could be loaded with a test message) matches the contents of the corresponding Comm-B register requested.

During the Comm-B protocol test procedure (Procedure #18) or as an extension of the above test, use a TCAS Crosslink type interrogation to extract the ground-initiated Comm-B registers in order to verify the Crosslink protocol operates and correctly reports the proper ground-initiated Comm-B data as the transponder changes Comm-B protocol state (if done as part of Procedure #18, interrogate with UF=0, RL=1, DS = 1 -255 when interrogating with ground MB extraction).

2.6 Test Procedures for Elementary Surveillance (ELS) Compliant Transponder (§2.2.24)

No test procedure required for this section, since §2.2.24 is introductory material for Elementary Surveillance (ELS).

2.6.1 Ground Initiated Comm-B (§2.2.24.1)

No test procedure required as multiple GICB extractions of the applicable registers are performed in subsequent tests.

2.6.2 Surveillance Identifier ("SI") Code Requirements (§2.2.24.2 and §2.2.24.2.1)

a. Perform Procedure #4 - Non-Selective Lockout Tests for all "II" and "SI" codes as required by §2.5.4.4 (see §2.2.18.2.4).

b. Perform Procedure #5 - Selective Lockout Tests for all "II" and "SI" codes as required by §2.5.4.5 (see §2.2.18.2.5).

Note: *Extraction of a Register or a Comm-B broadcast using an SI code is performed in §2.6.6.1.*

2.6.2.1 MOPS Requirements Relevant to "SI" (§2.2.24.2.1)

Appropriate test requirements to validate "SI" functions were previously provided in §2.6.2.

2.6.3 Declaration of Capability in Register 10_{16} – Data Link Capability Report (§2.2.24.3)

No test procedure required for this section.

2.6.3.1 Purpose and Definition (§2.2.24.3.1)

No direct test procedure required since the format of each required bit in Register 10_{16} is verified in subsequent tests.

2.6.3.2 Data Requirements (§2.2.24.3.2)

Introduction:

The purpose of this procedure is to verify the setting of the Data Link Capability Report as required in §2.2.24.3.2 when no capability has been established. The setting of the appropriate bits in Register 10_{16}, as capability is established or changed, is demonstrated or verified in subsequent sections.

Test Procedure:

Ensure that NO Aircraft Identification or Aircraft Registration data is being provided to the transponder.

Ensure that the TCAS / Transponder interface is NOT ACTIVE. If the interface is active, TCAS will provide data to set the Data Link Capability and thereby compromise the results of the following tests. Likewise, TCAS could attempt to set the Resolution Advisory Report and thereby compromise the results of the following tests.

Ensure that no other data is being provided to the transponder that could result in the loading of BDS registers internal to the transponder.

Disable the Extended Squitter and Mode-S Specific Services ("MSSS") functions prior to starting the following procedures in order to keep from setting various BDS registers during the following tests.

2.6.3.2.1 Bits 1 through 8, BDS Code (§2.2.24.3.2.1)

<u>Test Procedure:</u>

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 10_{16} Data Link Capability Report.

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 --- 32
				"SD"	
"UF" **=**	**"PC"** **=**	**"RR"** **=**	**"DI"** **=**	**"IIS"** **=**	**"NOT ASSIGNED"** **=**
4	0	**17** (11 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with bits 33 through 40 ("BDS" subfield [bits 1 through 8 of the "MB" field] set to 10 HEX (0001 0000 binary).

2.6.3.2.2 Bits 17 through 23, Declaration of Mode S Subnetwork Number (§2.2.24.3.2.2)

<u>Test Procedure:</u>

Continue to interrogate the transponder as required in §2.6.3.2.1. Verify that the transponder replies with a DF=20 reply with bits 49 - 55 ("Mode S Subnetwork Version Number" subfield [bits 17 - 23 of the "MB" field]) encoded with a value of "5" or more.

2.6.3.2.3 Bit 25, Declaration of No Mode S Specific Services Capability (§2.2.24.3.2.3)

<u>Test Procedure:</u>

Continue to interrogate the transponder as required in §2.6.3.2.1.

Verify that the transponder replies with a DF=20 reply with bit 57 (Mode S Specific Services Capability [bit 25 of the "MB" field]) set to ZERO (0) to indicate NO Mode S Specific Services Capability.

<u>Note:</u> *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

2.6.3.2.4 Bit 33, Aircraft Identification Reporting Capability (§2.2.24.3.2.4)

<u>Test Procedure:</u>

Continue to interrogate the transponder as required in §2.6.3.2.1.

Verify that the transponder replies with a DF=20 reply with bit 65 ("AIS" subfield [bit 33 of the "MB" field]) set to ZERO (0) to indicate NO Aircraft Identification capability.

2.6.3.2.5 Bit 35, Surveillance Identifier Code (“SI”) (§2.2.24.3.2.5)

Test Procedure:

Continue to interrogate the transponder as required in §2.6.3.2.1.

Verify that the transponder replies with a DF=20 reply with bit 67 (Surveillance Identifier (SI) [bit 35 of the “MB” field]) set to ONE (1) to indicate that the transponder DOES HAVE “SI” Capability.

2.6.3.2.6 Bit 36, Common Usage GICB Capability Report (§2.2.24.3.2.6, §2.2.24.4)

Test Procedure:

Continue to interrogate the transponder as required in §2.6.3.2.1.

Verify that the transponder replies with a DF=20 reply with bit 68 (Common Usage GICB Capability Report [bit 36 of the “MB” field]) set to ZERO (0) to indicate that there has been no change in the Common Usage GICB Capability Report, Register 17_{16}.

2.6.4 Register 17_{16} Common Usage GICB Capability Report (§2.2.24.4)

No test procedure required for this section.

2.6.4.1 Purpose and Definition (§2.2.24.4.1)

No direct test procedure is required for this section since the format of each required bit in Register 17_{16} is verified in subsequent tests.

2.6.4.2 Data Requirements (§2.2.24.4.2)

Introduction:

The purpose of this procedure is to verify the setting of the Common Usage GICB Capability Report as required in §2.2.24.4.2 when no capability has been established. The setting of appropriate bits in Register 17_{16}, as capability is established or changed, is demonstrated or verified in subsequent sections.

Test Procedure:

Ensure that the conditions established in §2.6.3.2 are retained.

2.6.4.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16} and 21_{16} as an Option (§2.2.24.4.2.1 and §2.2.24.4.2.2)

Test Procedure:

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report.

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

a. Bits 33 through 60 (bits 1 through 28 of the "MB" field) set to ZERO (0) to indicate NO Capability or capability changes in the Common Usage GICB Capability Report, Register 17_{16}.

b. Bits 61 through 88 (bits 29 - 56 of the "MB" field) set to ZERO (0) since these bits are Reserved or "Don't Care".

2.6.4.2.2 Required Servicing of Register 17_{16} Associated with Optional Register 21_{16} (§2.2.24.4.2.2)

Appropriate procedures to validate the setting of Register 17_{16} bits associated with Register 21_{16} prior to establishing any capability in the transponder installation were demonstrated in (§2.6.4.2.1).

2.6.5 Register 18_{16} to $1C_{16}$, Mode S Specific Services Capability Reports (§2.2.24.5)

No test procedure is required for this section.

2.6.5.1 Purpose and Definition (§2.2.24.5.1)

No direct test procedure is required for this section since the format of each required bit in Registers 18_{16} through $1C_{16}$ are verified in subsequent test.

2.6.5.2 Data Requirements (§2.2.24.5.2)

Introduction:

The purpose of this procedure is to verify the settings of the Mode S Specific Services Capability Reports as required in §2.2.24.5.2 when no capability has been established. The setting of appropriate bits in Registers 18_{16} through $1C_{16}$ as capability is established or changed is demonstrated or verified in subsequent sections.

2.6.5.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16} (§2.2.24.1 and §2.2.24.5.2.1)

Test Procedure:

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services Capability Report.

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 - 56 of the "MB" Field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 18_{16}.

2.6.5.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16} (§2.2.24.5.2.2)

Appropriate procedures to validate the setting of Register 18_{16} bits associated with Register 17_{16} prior to establishing any capability in the transponder installation were demonstrated in §2.6.5.2.1.

2.6.5.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16} (§2.2.24.5.2.3)

Appropriate procedures to validate the setting of Register 18_{16} bits associated with Register 18_{16} prior to establishing any capability in the transponder installation were demonstrated in §2.6.5.2.1.

2.6.5.2.4 Required Servicing of Register 18_{16} Associated with Register 20_{16} (§2.2.24.5.2.4)

Appropriate procedures to validate the setting of Register 18_{16} bits associated with Register 20_{16} prior to establishing any capability in the transponder installation were demonstrated in §2.6.5.2.1.

2.6.5.2.5 Required Servicing of Register 18_{16} Associated with Register 21_{16} (§2.2.24.5.2.5)

Appropriate procedures to validate the setting of Register 18_{16} bits associated with Register 21_{16} prior to establishing any capability in the transponder installation were demonstrated in §2.6.5.2.1.

2.6.5.3 Mode S Specific Services Capability Report, Register 19_{16} (§2.2.24.1 and §2.2.24.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services Capability Report.

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 19_{16}.

2.6.5.4 Mode S Specific Services Capability Report, Register $1A_{16}$ (§2.2.24.1 and §2.2.24.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1A_{16}$ Mode S Specific Services Capability Report.

REGISTER $1A_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**A**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register $1A_{16}$.

2.6.5.5 Mode S Specific Services Capability Report, Register $1B_{16}$ (§2.2.24.1 and §2.2.24.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1B_{16}$ Mode S Specific Services Capability Report.

REGISTER $1B_{16}$, MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACT. EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**B**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 - 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register $1B_{16}$.

2.6.5.6 Mode S Specific Services Capability Report, Register $1C_{16}$ (§2.2.24.1 and §2.2.24.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1C_{16}$ Mode S Specific Services Capability Report.

REGISTER $1C_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**C**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 through 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register $1C_{16}$.

Note: *Up to this point, the ELS Test Procedures have been written sequentially so as to align with the sequence of the requirements given in §2.2.24. This was possible up to this point as neither Aircraft Identification nor Aircraft Registry data has been provided to the unit under test. Once data is being provided to the unit under test, the changing of the data drives changes into multiple Registers at virtually the same time. This presents a problem in attempting to develop test procedures that sequentially track the requirements which have been stated on a Register basis as opposed to a functional basis. Therefore, the remainder of the ELS Test Procedures are developed on a functional basis with traceability to the requirements in §2.2.24 indicated in the procedures as appropriate.*

2.6.6 Baseline Aircraft Identification and Aircraft Registration Testing (§2.2.24.6 and §2.2.24.7)

No test procedure is required for this section since such procedures are provided in the following subparagraphs.

2.6.6.1 Part 1: Aircraft Identification and Aircraft Registration Startup (§2.2.24.6 and §2.2.24.7)

Note 1: *This Part 1 includes validation that back to back broadcasts are generated by the transponder. The first broadcast for the change in Aircraft Identification data in Register 20_{16} and the second broadcast for the change in Data Link Capability in Register 10_{16} caused by the change in Register 10_{16}. Subsequent Parts of §2.6 do not need to validate both broadcasts.*

Note 2: *Review all subparagraphs of Part 1 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Initialization:** (§2.2.24.6.2.1, §2.2.24.6.3.a, and §2.2.24.7.2)

(1). Provide the transponder with Aircraft Identification Data as specified in the following table at a maximum update interval of 1.5 seconds for each character provided.

Aircraft Identification Input Data				
Character Number (see Note 1)	**Character**	**IA-5 Encoding (see Note 2)**	**DO-181E Encoding (see Note 3)**	**LSB Encoding (see Note 4)**
1	"U"	1010101	010101	1010101
2	"J"	1001010	001010	0101001
3	"U"	1010101	010101	1010101
4	"J"	1001010	001010	0101001
5	"U"	1010101	010101	1010101
6	"J"	1001010	001010	0101001
7	"U"	1010101	010101	1010101
8	"J"	1001010	001010	0101001
9	"X"	1011000	011000	0001101
10	"Y"	1011001	011001	1001101

Notes:

1. *Aircraft Identification only uses eight characters in the downlink "MB" field; however, some equipment has indicated that ten input characters may be desired in the future. Therefore, this table provides for up to ten input characters.*
2. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
3. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, ….. b2, b1.).*
4. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

(2). **<u>If Implementing Aircraft Registration:</u>**

Provide the transponder with Aircraft Registration Data as specified in the following table at a maximum update interval of 1.5 seconds for each character provided.

Aircraft Registration Input Data				
Character Number	**Character**	**IA-5 Encoding (see Note 1)**	**DO-181E Encoding (see Note 2)**	**LSB Encoding (see Note 3)**
1	"J"	1001010	001010	0101001
2	"U"	1010101	010101	1010101
3	"J"	1001010	001010	0101001
4	"U"	1010101	010101	1010101
5	"J"	1001010	001010	0101001
6	"U"	1010101	010101	1010101
7	"J"	1001010	001010	0101001
8	"U"	1010101	010101	1010101
9	"J"	1001010	001010	0101001

<u>Notes:</u>

1. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
2. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, ….. b2, b1.).*
3. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

b. **<u>Comm-B Broadcast and Aircraft Identification Verification:</u>** (§2.2.24.3.3, §2.2.24.6.2.1 and §2.2.24.6.5)

For up to 10.0 seconds after completing Part 1, Step a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification.

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	**18** (12 HEX)	**0**	0	0

<u>Note 1:</u> *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated when Aircraft Identification Data is changed.*

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note 2: *The 5 seconds is based on the update rate specified for Register 20_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). And the "MB" field of the reply provides Aircraft Identification Data as follows:

Note 3: *DR= 4, 5, 6, or 7 indicates that Broadcast information is available.*

Part 1. b.(2) DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

As soon as DR= 4, 5, 6, or 7 is observed, start a Test Timer in order to monitor the "B" timer.

Note 4: *At this time, the "B" timer should be running because of the annunciation of a broadcast, because of a change in the contents of Register 20_{16}. The annunciation should persist for 18 ±1 second.*

c. **Comm-B Broadcast Extraction because of Aircraft Identification Change:** (§2.2.24.3.2.1, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.3.b, §2.2.24.3.4 and §2.2.24.6.3)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 1, Step b, interrogate the transponder with the following Comm-B Broadcast Extraction interrogations in order to extract the Comm-B broadcast message which should be the Aircraft Identification contained in Register 20_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with the "MB" field providing Aircraft Identification data as follows:

Part 1. c. DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

Repeat the following interrogation in order to extract the Comm-B broadcast message using an SI code (DI=3).

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14 - 16	17 - 22	23	24-27	28 --- 32
				"SD"			
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"SIS"** =	**"LSS"** =	**"RRS"** =	**"XX"** =
4	**0**	**16** (10 HEX)	**3**	**1**	**1**	**0**	**0**

Verify that the transponder replies with a "DF" = 20 reply with the "MB" field providing Aircraft Identification data as follows:

Part 1. c. DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

d. **Comm-B Broadcast because of Data Link Capability Change Extraction:** (§2.2.24.3.2.1, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.3.b, §2.2.24.3.4 and §2.2.24.6.3)

Continue to interrogate the transponder with the interrogation described in Part 1. c. (e.g., the last step) until the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ONE (1) to indicate Aircraft Identification capability.

(4). Bit 67 [Surveillance Identifier (SI) (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder DOES Have "SI" Capability.

Note 1: *At this time, the "B" timer started in Part 1.b. should have expired and a second (e.g., new) "B" Timer started to annunciate a Datalink Capability Report Change for 18 ±1 seconds. Verification that the first "B" Timer has expired is demonstrated by the transponder replying with the contents of Register 10_{16} as opposed to Register 20_{16}.*

As soon as the reply specified above in this step is observed, start a new Test Timer in order to monitor the "B" timer.

Verify that the elapsed time of the Test Timer started in Part 1.b is 18 ±1 second.

e. **Comm-B Broadcast because of Data Link Capability Change Termination:**

Continue to interrogate the transponder with the interrogation described in Part 1. c. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 1.d (e.g., the last step) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 1.d, as broadcast because of a change in Data Link Capability, should have terminated.*

f. **Aircraft Registration Verification: (Optional)** (§2.2.24.7.1, §2.2.24.7.2 and §2.2.24.7.3)

Note 1: *Servicing of Register 21_{16} is Optional.*

Stop providing data as specified in Part 1, Step a.(2) for a period of 20 seconds, then restart providing the same data to the transponder.

Within 15 seconds of providing such Aircraft Registration data interrogate the transponder with the following GICB Extraction interrogations in order to extract the Register 21_{16} - Aircraft Registration.

Note 2: *The 15 seconds is based on the update rate specified for Register 21_{16}.*

REGISTER 21_{16} AIRCRAFT REGISTRATION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**18** (12 HEX)	**7**	0	**1**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having the following "MB" field:

Part 1. f DF = 20, Register 21_{16} - Aircraft Registration "MB" Field											
Reply Bits:	33	34 -- 39	40 -- 45	46 -- 51	52 -- 57	58 -- 63	64 -- 69	70 --75	76	77 -- 82	83 -- 88
"MB" Bits:	1	2 -- 7	8 -- 13	14 -- 19	20 -- 25	26 -- 31	32 -- 37	38 -- 43	44	45 -- 50	51 – 56
Field:	**Status**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Status**	**Char. 1**	**Char. 2**
Data:	1	001010	010101	001010	010101	001010	010101	001010	0	000000	000000
Character:		**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**			

g. **Data Link Capability Report, Register 10_{16}:** (§2.2.24.3.1, §2.2.24.3.2.1, §2.2.24.3.2.3, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.2.6, §2.2.24.3.3.b, §2.2.24.4 and §2.2.24.6.4.1)

Discontinue providing the transponder with Aircraft Identification (Part 1, Step a.(1)) and Aircraft Registration data (Part 1, Step a.(2)). Then Repeat Part 1, Step a. and Step "b."

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 1, Step "b" in accordance with the previous paragraph, interrogate the transponder with the following GICB Extraction interrogations in order to extract the Register 10_{16} Data Link Capability Report.

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	**17** (11 HEX)	**0**	0	0

Within 66 seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 66 seconds is based on the update rate specified for Register 17_{16} plus the update time of up to 60 seconds for Register 10_{16} to update Bit 68.*

(1). Bit 33 through 40 (bit 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(2). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ONE (1) to indicate Aircraft Identification capability.

(3). Bit **57** [Mode S Specific Services Capability (bit 25 of the "MB" field)] set to ZERO (0) to indicate NO Mode S Specific Services Capability.

Note 1: *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

Note 2: *If Register 21_{16} is being serviced, then Bit 57 (bit 25 of the "MB" field) is set to ONE (1).*

(4). Bit 67 [Surveillance Identifier (SI) (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder DOES Have "SI" Capability.

(5). Bit 68 [Common Usage GICB Capability Report (bit 36 of the "MB" field)] set to ONE (1) to indicate that there has been a change in the Common Usage GICB Capability Report, Register 17_{16}.

h. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.24.4.2, §2.2.24.4.3, §2.2.24.6.4.2 and §2.2.24.7.4.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 5 seconds is based on the update rate specified for Register 17_{16}.*

(1). Bit 39 (bit 7 of the "MB" field) set to ONE (1) to indicate that Aircraft Identification Capability is established.

(2). Bit 40 (bit 8 of the "MB" field) set to ONE (1) to indicate that Aircraft Registration Capability is established.

Note: *If Register 21_{16} is not being serviced, then Bit 40 (bit 8 of the "MB" field) is set to ZERO (0).*

Repeat the extraction of Register 17_{16} using the following GICB extraction interrogation in order to use the format for SI code (DI=3) and verify that the content is the same as the content of Register 17_{16} previously extracted using DI=7.

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14 - 16	17 - 22	23	24-27	28 --- 32
				"SD"			
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"SIS" =**	**"LSS" =**	**"RRS" =**	**Not Assigned =**
4	**0**	**17** (11 HEX)	**3**	**1**	**1**	**7**	**0**

i. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.24.5.2, §2.2.24.5.3.a and b, §2.2.24.6.4.3 and §2.2.24.7.4.2)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 1, Step b as required in Part 1, Step g, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 5 seconds is based on the update rate specified for Register 18_{16}.*

(1). Bit 73 (bit 41 of the “MB” field) set to ONE (1) to indicate that Data Link Capability 10_{16} is established.

(2). Bit 57 (bit 25 of the “MB” field) set to ONE (1) to indicate that Aircraft Identification Capability 20_{16} is established.

(3). Bit 56 (bit 24 of the “MB” field) set to ONE (1) to indicate that Aircraft Registration Capability 21_{16} is established.

(4). Bit 66 (bit 34 of the “MB” field) set to ONE (1) to indicate that Register 17_{16} Servicing Capability is established.

(5). Bit 65 (bit 33 of the “MB” field) set to ONE (1) to indicate that Register 18_{16} Servicing Capability is established.

Repeat the extraction of Register 18_{16} using the following GICB extraction interrogation in order to use the format for SI code (DI=3) and verify that the content is the same as the content of Register 18_{16} previously extracted using DI=7.

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14 - 16	17 - 22	23	24-27	28 --- 32
				“SD”			
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“SIS”** =	**“LSS”** =	**“RRS”** =	**Not Assigned** =
4	**0**	**17** (11 HEX)	**3**	**1**	**1**	**8**	**0**

2.6.6.2 Part 2: Aircraft Identification Data Termination

Note 1: *This Part 2 validates that character data in Register 20_{16} is set to zero when Aircraft Identification data is lost and not replaced by Aircraft Registration data if such data is available.*

Note 2: *Review all subparagraphs of Part 2 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Aircraft Identification Data Termination:** (§2.2.24.6.2.1 and §2.2.24.7.2)

Discontinue the provision of Aircraft Identification data to the transponder. Continue to provide Aircraft Registration data as required in Part 1.a. and restarted in Part 1.g.

b. **Comm-B Broadcast and Aircraft Identification Verification:** (§2.2.24.6.2.1 and §2.2.24.6.5)

For up to 10.0 seconds after completing Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification.

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ---------- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**0**	0	0

Note 1: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated when Aircraft Identification Data is changed.*

Within TEN (10) seconds of completing Part 2.a, verify that the transponder replies with a DF=20 reply with:

Note 2: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). And the "MB" field of the reply provides Aircraft Identification Data as follows:

Part 2. b.(2) DF = 20, Register 20_{16} - Aircraft Identification "MB" Field								
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	000000	000000	000000	000000	000000	000000	000000	000000
Character:		**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**

c. **Comm-B Broadcast Extraction:** (§2.2.24.3.2.1, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.3.a and b , §2.2.24.3.4 and §2.2.24.6.3)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 2, Step b, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate loss of Aircraft Identification capability.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.24.4.1, §2.2.24.4.2, §2.2.24.4.3, §2.2.24.7.1 and §2.2.24.7.2)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 2, Step b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 5 seconds is based on the update rate specified for Register 17_{16}.*

(1). Bit 39 (bit 7 of the "MB" field) set to ZERO (0) to indicate that Aircraft Identification Capability has changed.

(2). Bit 40 (bit 8 of the "MB" field) set to ONE (1) to indicate that Aircraft Registration Capability is established.

Note: *Bit 40 will be set to ZERO (0) if Aircraft Registration data is not being provided as provision of such data is optional.*

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.24.3.1, §2.2.24.3.2.1, §2.2.24.3.2.3, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.2.6, §2.2.24.5.1, §2.2.24.5.2.3, §2.2.24.5.3 and §2.2.24.6.4.3)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 2, Step b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 5 seconds is based on the update rate specified for Register 18_{16}.*

(1). Bit 57 (bit 25 of the “MB” field) set to ONE (1) to indicate that Aircraft Identification Capability is established.

(2). Bit 56 (bit 24 of the “MB” field) set to ONE (1) to indicate that Aircraft Registration Capability is established.

Note: *Bit 56 will be set to ZERO (0) if Aircraft Registration data is not being provided as provision of such data is optional.*

(3). Bit 66 (bit 34 of the “MB” field) set to ONE (1) to indicate that Register 17_{16} Servicing Capability is established.

(4). Bit 65 (bit 33 of the “MB” field) set to ONE (1) to indicate that Register 18_{16} Servicing Capability is established.

2.6.6.3 Part 3: Power-On Restart (NO Aircraft Ident.)

Note 1: *This Part 3 verifies that Optional Aircraft Registration data (if provided) is used at power-on for Aircraft Identification if actual Aircraft Identification data is not provided.*

Note 2: *Review all subparagraphs of Part 3 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Power-On Restart:** (§2.2.24.6.2.1 and §2.2.24.7.2)

Remove power from the transponder for approximately 10 seconds.

Continue application of Aircraft Registration data to the transponder as defined in Part 1.a. Do not re-apply Aircraft Identification data to the transponder at this time. Re-apply power to the transponder.

b. **Comm-B Broadcast and Aircraft Identification Verification:** (§2.2.24.3.3, §2.2.24.6.2.1 and §2.2.24.6.5)

For up to 10.0 seconds after completing Part 3.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification (now Aircraft Registration) data.

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 --- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**0**	0	0

Note 1: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated when Aircraft Identification Data is changed.*

Within TEN (10) seconds of completing Part 3.a, verify that the transponder replies with a DF=20 reply with:

Note 2: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). And the "MB" field of the reply provides Aircraft Identification (now Aircraft Registration) Data as follows:

Part 3. b.(2) DF = 20, Register 20_{16} - Aircraft Identification (now Aircraft Registration) "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	001010	010101	001010	010101	001010	010101	001010	010101
Character:		**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**

c. **Comm-B Broadcast Extraction:** (§2.2.24.3.2.1, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.3.b, §2.2.24.3.4 and §2.2.24.6.3)

Note 1: *This test does not repeat testing of the timing of the "B" Timer as was done in Part 1. Rather, it is intended only to demonstrate that the broadcast is generated and contains the proper information.*

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 3, Step b, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

<u>Note 2:</u> *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ONE (1) to indicate Aircraft Identification capability.

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.24.4.2, §2.2.24.4.3, §2.2.24.6.4.2 and §2.2.24.7.4.1)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 3, Step b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

<u>Note:</u> *The 5 seconds is based on the update rate specified for Register 17_{16}.*

(1). Bit 39 (bit 7 of the "MB" field) set to ONE (1) to indicate that Aircraft Identification Capability has changed.

(2). Bit 40 (bit 8 of the "MB" field) set to ONE (1) to indicate that Aircraft Registration Capability is established.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.24.5, §2.2.24.6.4.3 and §2.2.24.7.4.2)

As soon as the transponder has replied with the proper Register 20_{16} reply in Part 3, Step b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Within FIVE (5) seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 5 seconds is based on the update rate specified for Register 18_{16}.*

(1). Bit 57 (bit 25 of the "MB" field) set to "1" to indicate that Aircraft Identification Capability has been established during the power-on cycle.

(2). Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Aircraft Registration Capability is established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} Servicing Capability is established.

(4). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} Servicing Capability is established.

2.6.6.4 Part 4: Re-Apply Aircraft Identification

Note 1: *This Part 4 verifies that Aircraft Identification data will replace Aircraft Registration data once such Aircraft Identification data is available.*

Note 2: *Review all subparagraphs of Part 4 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Aircraft Identification Restart:** (§2.2.24.6.2.1 and §2.2.24.7.2)

Continue application of Aircraft Registration data to the transponder as defined in Part 1.a. Re-apply Aircraft Identification data to the transponder as defined in Part 1.a.

b. **Comm-B Broadcast and Aircraft Identification Verification:** (§2.2.24.3.3, §2.2.24.6.2.1 and §2.2.24.6.5)

For up to 10.0 seconds after completing Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

Note: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ---------- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**7**	0	0

Within TEN (10) seconds of completing Part 4.a, verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). And the "MB" field of the reply provides Aircraft Identification Data as follows

Part 4. b.(2) DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

c. **Comm-B Broadcast Extraction:** (§2.2.24.3.2.1, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.3.b, §2.2.24.3.4 and §2.2.24.6.3)

Note: *This test does not repeat testing of the timing of the "B" Timer as was done in Part 1. Rather, it is intended only to demonstrate that the broadcast is generated and contains the proper information.*

Interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Aircraft Identification contained in Register 20_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). And the "MB" field of the reply provides Aircraft Identification Data as follows

Part 4. c.(2) DF = 20, Register 20_{16} - Aircraft Identification - "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.24.4.2, §2.2.24.4.3, §2.2.24.6.4.2 and §2.2.24.7.4.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 39 (bit 7 of the "MB" field) set to "1" to indicate that Aircraft Identification Capability has changed.

(2). Bit 40 (bit 8 of the "MB" field) set to "1" to indicate that Aircraft Registration Capability is established.

e. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.24.5, §2.2.24.6.4.3 and §2.2.24.7.4.2)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 57 (bit 25 of the "MB" field) set to "1" to indicate that Aircraft Identification Capability has been established during the power-on cycle.

(2). Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Aircraft Registration Capability is established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} Servicing Capability is established.

(4). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} Servicing Capability is established.

2.6.6.5 Part 5: Data Mix #1

Note: *Review all subparagraphs of Part 5 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Mix #1 Initialization:** (§2.2.24.6.2.1 and §2.2.24.7.2)

(1). Provide the transponder with Aircraft Identification Data as specified in the following table at a maximum update interval of 1.5 seconds for each character provided.

Aircraft Identification Input Data				
Character Number (See Note 1)	**Character**	**IA-5 Encoding (See Note 2)**	**DO-181E Encoding (See Note 3)**	**LSB Encoding (See Note 4)**
1	"6"	0110110	110110	0110110
2	"SP"	0100000	100000	0000010
3	"9"	0111001	111001	1001110
4	"SP"	0100000	100000	0000010
5	"6"	0110110	110110	0110110
6	"SP"	0100000	100000	0000010
7	"9"	0111001	111001	1001110
8	"SP"	0100000	100000	0000010
9	"X"	1011000	011000	0001101
10	"Y"	1011001	011001	1001101

Notes:
1. *Aircraft Identification only uses eight characters in the downlink "MB" field; however, some equipments have indicated that ten input characters may be desired in the future. Therefore, this table provides for up to ten input characters.*
2. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
3. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, …..b2, b1.).*
4. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

(2). **If Implementing Aircraft Registration:**

Provide the transponder with Aircraft Registration Data as specified in the following table at a maximum update interval of 1.5 seconds for each character provided.

Aircraft Registration Input Data				
Character Number	**Character**	**IA-5 Encoding (See Note 1)**	**DO-181E Encoding (See Note 2)**	**LSB Encoding (See Note 3)**
1	"W"	1010111	010111	1110101
2	"X"	1011000	011000	0001101
3	"SP"	0100000	100000	0000010
4	"Y"	1011001	011001	1001101
5	"Z"	1011010	011010	0101101
6	"SP"	0100000	100000	0000010
7	"4"	0110100	110100	0010110
8	"2"	0110010	110010	0100110
9	"SP"	0100000	100000	0000010

Notes:

1. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
2. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, …..b2, b1.).*
3. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

b. **Aircraft Identification Verification:** (§2.2.24.6.1 and §2.2.24.6.2.1)

For up to **10.0** seconds after completing Part 5.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

Note: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ------ 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**0**	0	0

Within TEN (10) seconds of completing Part 5.a, verify that the transponder replies with a DF=20 reply with:

Part 5. b. DF = 20, Register 20_{16} - Aircraft Identification "MB" Field								
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	110110	111001	110110	111001	011000	011001	100000	100000
Character:		**"6"**	**"9"**	**"6"**	**"9"**	**"X"**	**"Y"**	**"SP"**	**"SP"**

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

REGISTER 20_{16} AIRCRAFT REGISTRATION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP							
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 – 22	23	24 – 27	28 - 32
				"SD"			
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"SIS" =**	**"LSS" =**	**"RRS" =**	**"XX" =**
4	0	**18** (12 HEX)	**3**	1	0	**0**	0

Verify that the transponder replies with a DF=20 reply having the same content as the Part 5.b table above.

c. **<u>Aircraft Registration Verification:</u>** (§2.2.24.6.2.1, §2.2.24.7.1 and §2.2.24.7.2)

Within 30.0 seconds of completing Part 5.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 21_{16} - Aircraft Registration.

REGISTER 21_{16} AIRCRAFT REGISTRATION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**18** (12 HEX)	**7**	0	**1**	0	0	0	0

Verify that the transponder replies with a DF=20 reply and that the "MB" field of the reply provides Aircraft Registration Data as follows:

Part 5. c. DF = 20, Register 21_{16} - Aircraft Registration "MB" Field											
Reply Bits:	33	34 -- 39	40 -- 45	46 -- 51	52 -- 57	58 -- 63	64 -- 69	70 --75	76	77 -- 82	83 -- 88
"MB" Bits:	1	2 -- 7	8 -- 13	14 -- 19	20 -- 25	26 -- 31	32 -- 37	38 -- 43	44	45 -- 50	51 – 56
Field:	**Status**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Status**	**Char. 1**	**Char. 2**
Data:	1	010111	011000	011001	011010	110100	110010	100000	0	000000	000000
Character:		**"W"**	**"X"**	**"Y"**	**"Z"**	**"4"**	**"2"**	**"SP"**			

2.6.6.6 Part 6: Data Mix #2

<u>Note:</u> *Review all subparagraphs of Part 6 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data Mix #2 Initialization:</u>** (§2.2.24.6.2.1 and §2.2.24.7.2)

(1). Provide the transponder with Aircraft Identification Data as specified in the following table at a minimum rate of once per second for each character provided.

Aircraft Identification Input Data				
Character Number (see Note 1)	**Character**	**IA-5 Encoding (see Note 2)**	**DO-181E Encoding (see Note 3)**	**LSB Encoding (see Note 4)**
1	"SP"	0100000	100000	0000010
2	"SP"	0100000	100000	0000010
3	"SP"	0100000	100000	0000010
4	"SP"	0100000	100000	0000010
5	"D"	1000100	000100	0010001
6	"L"	1001100	001100	0011001
7	"SP"	0100000	100000	0000010
8	"4"	0110100	110100	0010110
9	"SP"	0100000	100000	0000010
10	"5"	0110101	110101	1010110

Notes:

1. *Aircraft Identification only uses eight characters in the downlink "MB" field; however, some equipment has indicated that ten input characters may be desired in the future. Therefore, this table provides for up to ten input characters.*
2. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
3. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, ….. b2, b1.).*
4. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

(2). Provide the transponder with Aircraft Registration Data as specified in the following table at a minimum rate of once per second for each character provided.

Aircraft Registration Input Data				
Character Number	**Character**	**IA-5 Encoding (See Note 1)**	**DO-181E Encoding (See Note 2)**	**LSB Encoding (See Note 3)**
1	**"SP"**	0100000	100000	0000010
2	**"SP"**	0100000	100000	0000010
3	**"SP"**	0100000	100000	0000010
4	**"D"**	1000100	000100	0010001
5	**"L"**	1001100	001100	0011001
6	**"SP"**	0100000	100000	0000010
7	**"4"**	0110100	110100	0010110
8	**"4"**	0110100	110100	0010110
9	**"SP"**	0100000	100000	0000010

Notes:

1. *IA-5 refers to International Alphabet No. 5 (IA-5) as provided in Table 8-2 of ICAO Annex 10, Volume III, Part 1, last update. Encoding is shown above being MSB left justified (e.g., b7, b6, …….b2, b1.).*
2. *DO-181E encoding refers to DO-181E §2.2.19.1.13.f encoding, which is equivalent to ICAO Annex 10, Volume IV, §3.1.2.9.1.2, Table 3-7. Encoding is shown above being MSB left justified (e.g., b6, b5, …..b2, b1.).*
3. *LSB Encoding shows the IA-5 Encoding reversed with the LSB being Left Justified. This encoding is typical of serial input protocols which transmit data LSB first.*

b. **Aircraft Identification Verification:** (§2.2.24.6.1 and §2.2.24.6.2.1)

Within TEN (10) seconds of completing Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

Note: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ---- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**0**	0	0

Within TEN (10) seconds of completing Part 6.a, verify that the transponder replies with a DF=20 reply with:

Part 6. b. DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	000100	001100	110100	110101	100000	100000	100000	100000
Character:		**"D"**	**"L"**	**"4"**	**"5"**	**"SP"**	**"SP"**	**"SP"**	**"SP"**

c. **Aircraft Registration Verification:** (§2.2.24.6.2.1, §2.2.24.7.1 and §2.2.24.7.2)

Within 30.0 seconds of completing Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 21_{16} - Aircraft Registration.

REGISTER 21_{16} AIRCRAFT REGISTRATION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**18** (12 HEX)	**7**	0	**1**	0	0	0	0

Verify that the transponder replies with a DF=20 reply and that the "MB" field of the reply provides Aircraft Registration Data as follows:

Part 6. c. DF = 20, Register 21_{16} - Aircraft Registration "MB" Field											
Reply Bits:	33	34 -- 39	40 -- 45	46 -- 51	52 -- 57	58 -- 63	64 -- 69	70 --75	76	77 -- 82	83 -- 88
"MB" Bits:	1	2 -- 7	8 -- 13	14 -- 19	20 -- 25	26 -- 31	32 -- 37	38 -- 43	44	45 -- 50	51 – 56
Field:	**Status**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Status**	**Char. 1**	**Char. 2**
Data:	1	000100	001100	110100	110100	100000	100000	100000	0	000000	000000
Character:		**"D"**	**"L"**	**"4"**	**"4"**	**"SP"**	**"SP"**	**"SP"**			

2.6.6.7 Part 7: Data Mix 3 – No Data

Note: *Review all subparagraphs of Part 8 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Mix #4 Initialization:** (§2.2.24.6.2.1 and §2.2.24.7.2)

(1). Disable the capability to provide the transponder with Aircraft Identification Data.

(2). Disable the capability to provide the transponder with Aircraft Registration Data.

b. **Aircraft Identification Verification:** (§2.2.24.6.1, §2.2.24.6.2.1 and §2.2.24.6.3)

Within TEN (10) seconds of completing Part 7.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

Note: *The 10 seconds is based on half the update rate specified for Register 20_{16}.*

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	**18** (12 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply and that the "MB" field of the reply provides Aircraft Identification Data as follows:

Part 7.b DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	000000	000000	000000	000000	000000	000000	000000	000000
Character:		**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**

c. **Aircraft Registration Verification:** (§2.2.24.6.2.1, §2.2.24.7.1, §2.2.24.7.2 and §2.2.24.7.3)

Within 30.0 seconds of completing Part 7.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 21_{16} - Aircraft Registration.

Note: *The 30 seconds is based on half the update rate specified for Register 21_{16}.*

REGISTER 21_{16} AIRCRAFT REGISTRATION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**18** (12 HEX)	**7**	0	**1**	0	0	0	0

Verify that the transponder replies with a DF=20 reply and that the "MB" field of the reply provides Aircraft Registration Data as follows:

Part 7.c DF = 20, Register 21_{16} - Aircraft Registration "MB" Field											
Reply Bits:	33	34 -- 39	40 -- 45	46 -- 51	52 -- 57	58 -- 63	64 -- 69	70 --75	76	77 -- 82	83 -- 88
"MB" Bits:	1	2 -- 7	8 -- 13	14 -- 19	20 -- 25	26 -- 31	32 -- 37	38 -- 43	44	45 -- 50	51 – 56
Field:	**Status**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Status**	**Char. 1**	**Char. 2**
Data:	1	000000	000000	000000	000000	000000	000000	000000	0	000000	000000
Character:		**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**	**"NUL"**			

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.24.4.2, §2.2.24.4.3, §2.2.24.6.4.2 and §2.2.24.7.4.1)

Within TEN (10) seconds of completing Part 7.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 39 (bit 7 of the "MB" field) set to ZERO (0) to indicate that Aircraft Identification Capability has been lost.

(2). Bit 40 (bit 8 of the "MB" field) set to ZERO (0) to indicate that Aircraft Registration Capability has been lost.

2.6.6.8 Part 8: Data Link Capability Report Update Interval (§2.2.24.3.3)

a. **Data Initialization:** (§2.2.24.6.2.1 and §2.2.24.6.3.a)

After completion of Part 7, re-apply Aircraft Identification Data as specified in Part 1.a.(1).

b. **Aircraft Identification Verification:** (§2.2.24.6.1 and §2.2.24.6.2.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 --- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	**18** (12 HEX)	**0**	0	0

Verify that the transponder replies with the following DF=20 reply:

Part 8.b DF = 20, Register 20_{16} - Aircraft Identification "MB" Field								
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

c. **<u>Data Link Capability Report, Register 10_{16}:</u>** (§2.2.24.3.1, §2.2.24.3.2.1, §2.2.24.3.2.3, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.2.6, §2.2.24.3.3.a and b, §2.2.24.4 and §2.2.24.6.4.1)

As soon as the transponder replies with the reply required in Part 8.b, interrogate the transponder with the following interrogation:

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 --- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	**17** (11 HEX)	**0**	0	0

Within ONE (1) second of initiating the above interrogation, verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(2). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ONE (1) to indicate Aircraft Identification capability.

(3). Bit 57 [Mode S Specific Services Capability (bit 25 of the "MB" field)] set to ZERO (0) to indicate NO Mode S Specific Services Capability.

<u>Note:</u> *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

(4). Bit 67 [Surveillance Identifier (SI) (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder DOES Have "SI" Capability.

d. **<u>Aircraft Identification Termination:</u>** (§2.2.24.6.2.1 and §2.2.24.6.3.a)

Terminate provisioning of the Aircraft Identification data started in Part 8.a.

e. **<u>Aircraft Identification Verification:</u>** (§2.2.24.6.1 and §2.2.24.6.2.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 20_{16} - Aircraft Identification data.

REGISTER 20_{16} AIRCRAFT IDENTIFICATION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**18** (12 HEX)	**0**	0	0

Verify that the transponder replies with the following DF=20 reply:

Part 8.e DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	000000	000000	000000	000000	000000	000000	000000	000000
Character:		**NULL**	**NULL**	**NULL**	**NULL**	**NULL**	**NULL**	**NULL**	**NULL**

f. **<u>Data Link Capability Report, Register 10_{16}:</u>** (§2.2.24.3.1, §2.2.24.3.2.1, §2.2.24.3.2.3, §2.2.24.3.2.4, §2.2.24.3.2.5, §2.2.24.3.2.6, §2.2.24.3.3.c, §2.2.24.4 and §2.2.24.6.4.1)

As soon as the transponder replies with the reply required in Part 8.b, interrogate the transponder with the following interrogation:

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**17** (11 HEX)	**0**	0	0

Within EIGHT (8) seconds of initiating the above interrogation, verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 - 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(2). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate NO Aircraft Identification capability.

(3). Bit 57 [Mode S Specific Services Capability (bit 25 of the "MB" field)] set to ZERO (0) to indicate NO Mode S Specific Services Capability.

<u>Note:</u> *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

(4). Bit 67 [Surveillance Identifier (SI) (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder DOES Have "SI" Capability.

2.6.6.9 Part 9: Multiple Data Sources (§2.2.24)

If Multiple Data Sources of Register 20_{16} and/or Register 21_{16} are provided to the Unit-Under-Test (UUT), then REPEAT all applicable sections of Part 5 and 6 for each additional data source that was not tested while performing Parts 1 through 7above.

2.7 Test Procedures for Enhanced Surveillance (EHS) Compliant Transponder (§2.2.25)

No test procedure is required for this section since §2.2.25 is introductory material for Enhanced Surveillance (EHS).

2.7.1 Register 10_{16} – Data Link Capability Report (§2.2.25.1)

2.7.1.1 Purpose and Definition (§2.2.25.1.1)

No direct test procedure is required for this section since the format of each required bit in Register 10_{16} is verified in subsequent tests.

2.7.1.2 Data Requirements (§2.2.25.1.2)

Introduction:

The purpose of this procedure is to verify the setting of the Data Link Capability Report as required in §2.2.25.1.2 when no capability has been established. The setting of appropriate bits in Register 10_{16} as capability is established or changed is demonstrated or verified in subsequent sections.

Test Procedure:

Note: *The primary intent of Part 1 is to validate appropriate capability declaration of No Capability prior to providing data to Register 40_{16}, 50_{16}, or 60_{16}.*

Ensure that NO Aircraft Identification or Aircraft Registration data is being provided to the transponder.

Ensure that the TCAS / Transponder interface is NOT ACTIVE. If the interface is active, TCAS will provide data to set the Data Link Capability and thereby compromise the results of the following tests. Likewise, TCAS could attempt to set the Resolution Advisory Report and thereby compromise the results of the following tests.

Ensure that no other data is being provided to the transponder that could result in the loading of BDS registers internal to the transponder.

Disable the Extended Squitter and Mode-S Specific Services ("MSSS") functions prior to starting the following procedures in order to keep from setting various BDS registers during the following tests.

2.7.1.2.1 Bits 1 through 8, BDS Code (§2.2.25.1.2.1)

Test Procedure:

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 10_{16} Data Link Capability Report.

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**17** (11 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with bits 33 through 40 ("BDS" subfield (bits 1 through 8 of the "MB" field)] set to 10 HEX (0001 0000 binary).

2.7.1.2.2 Bits 17 through 23, Declaration of Mode S Subnetwork Number (§2.2.25.1.2.2)

Test Procedure:

Continue to interrogate the transponder as required in §2.7.1.2.1. Verify that the transponder replies with a DF=20 reply with bits 49 through 55 ("Mode S Subnetwork Version Number" subfield [bits 17 through 23 of the "MB" field]) encoded with a value of "5" or more.

2.7.1.2.3 Bit 25, Declaration of No Mode S Specific Services Capability (§2.2.25.1.2.3)

Test Procedure:

Continue to interrogate the transponder as required in §2.7.1.2.1.

Verify that the transponder replies with a DF=20 reply with bit 57 (Mode S Specific Services Capability [bit 25 of the "MB" field]) set to ZERO (0) to indicate NO Mode S Specific Services Capability.

Note: *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

2.7.1.2.4 Bit 35, Surveillance Identifier Code ("SI") (§2.2.25.1.2.4)

Test Procedure:

Continue to interrogate the transponder as required in §2.7.1.2.1.

Verify that the transponder replies with a DF=20 reply with bit 67 (Surveillance Identifier (SI) [bit 35 of the "MB" field]) set to ONE (1) to indicate that the transponder DOES Have "SI" Capability.

2.7.1.2.5 Bit 36, Common Usage GICB Capability Report (§2.2.25.1.2.5)

Test Procedure:

Continue to interrogate the transponder as required in §2.7.1.2.1.

Verify that the transponder replies with a DF=20 reply with bit 68 (Common Usage GICB Capability Report [bit 36 of the "MB" field]) set to ZERO (0) to indicate that there has been no change in the Common Usage GICB Capability Report, Register 17_{16}.

2.7.1.3 Maximum Update Interval of Register 10_{16} (§2.2.25.1.3)

No direct test procedure is required at this time as EHS data has yet to be provided to the transponder. Appropriate update checks are made in subsequent sections as data is provided.

2.7.1.4 Change Reporting (§2.2.25.1.4)

No direct test procedure is required at this time as EHS data has yet to be provided to the transponder. Appropriate change reporting checks are made in subsequent sections as data is provided.

2.7.2 Register 17_{16}---Common Usage GICB Capability Report (§2.2.25.2)

No test procedure is required for this section.

2.7.2.1 Register 17_{16} – Purpose and Definition (§2.2.25.2.1)

No direct test procedure is required for this section since the format of each required bit in Register 17_{16} is verified in subsequent tests.

2.7.2.2 Enhanced Surveillance (EHS) Servicing Requirements (§2.2.25.2.2)

Introduction:

The purpose of this procedure is to verify the setting of the Common Usage GICB Capability Report as required in §2.2.25.2.2 when no capability has been established. The setting of appropriate bits in Register 17_{16} as capability is established or changed is demonstrated or verified in subsequent sections.

Test Procedure:

Ensure that the conditions established in §2.7.1.2 are retained.

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report.

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

a. Bits 33 - 60 (bits 1 - 28 of the "MB" field) set to ZERO (0) to indicate NO Capability or capability changes in the Common Usage GICB Capability Report, Register 17_{16}.

b. Bits 61 - 88 (bits 29 - 56 of the "MB" field) set to ZERO (0) since these bits are Reserved or "Don't Care".

2.7.2.2.1 Required Servicing of Register 17_{16} Associated with Register 20_{16} (§2.2.25.2.2.1)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Register 20_{16} were previously provided in §2.6.4.2.1, and are checked again in §2.7.2.2.

2.7.2.2.2 Required Servicing of Register 17_{16} Associated with Optional Register 21_{16} (§2.2.25.2.2.2)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Register 20_{16} were previously provided in §2.6.4.2.1 and are checked again in §2.7.2.2.

2.7.2.2.3 Required Servicing of Register 17_{16} Associated with Register 40_{16} (§2.2.25.2.2.3)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Register 40_{16} were previously provided in §2.7.2.2 for conditions where no data has been provided for Register 40_{16}. Verification of the settings of Register 17_{16} in regards to Register 40_{16} will be verified in subsequent sections as data is provided for Register 40_{16}.

2.7.2.2.4 Required Servicing of Register 17_{16} Associated with Register 50_{16} (§2.2.25.2.2.4)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Register 50_{16} were previously provided in §2.7.2.2 for conditions where no data has been provided for Register 50_{16}. Verification of the settings of Register 17_{16} in regards to Register 50_{16} will be verified in subsequent sections as data is provided for Register 50_{16}.

2.7.2.2.5 Required Servicing of Register 17_{16} Associated with Optional Register $5F_{16}$ (§2.2.25.2.2.5)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Optional Register $5F_{16}$ were previously provided in §2.7.2.2 for conditions where no data has been provided for Register $5F_{16}$. Verification of the settings of Register 17_{16} in regards to Optional Register $5F_{16}$ will be verified in subsequent sections as data is provided for Register $5F_{16}$.

2.7.2.2.6 Required Servicing of Register 17_{16} Associated with Register 60_{16} (§2.2.25.2.2.6)

Appropriate procedures to validate the initial state of Register 17_{16} in regards to Register 60_{16} were previously provided in §2.7.2.2 for conditions where no data has been provided for Register 60_{16}. Verification of the settings of Register 17_{16} in regards to Register 60_{16} will be verified in subsequent sections as data is provided for Register 60_{16}.

2.7.2.2.7 Maximum Update Interval of Register 17_{16} (§2.2.25.2.2.7)

No direct test procedure is required at this time as EHS data has yet to be provided to the transponder. Appropriate update checks are made in subsequent sections as data is provided.

2.7.2.3 Change Reporting (§2.2.25.2.3)

No direct test procedure is required at this time as EHS data has yet to be provided to the transponder. Appropriate change reporting checks are made in subsequent sections as data is provided.

2.7.3 Register 18_{16} to $1C_{16}$, Mode S Specific Services Capability Reports (§2.2.25.3)

No test procedures are required for this section.

2.7.3.1 Purpose and Definition (§2.2.25.3.1)

No direct test procedure is required for this section since the format of each required bit in Registers 18_{16} through $1C_{16}$ are verified in subsequent tests.

2.7.3.2 Enhanced Surveillance Capability Requirements (§2.2.25.3.2)

No test procedures are required for this section.

2.7.3.2.1 Required Servicing of Register 18_{16} Associated with Register 10_{16} (§2.2.25.3.2.1 through §2.2.25.3.2.6)

Test Procedure:

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services Capability Report.

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the “MB” Field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 18_{16}.

2.7.3.2.2 Required Servicing of Register 18_{16} Associated with Register 17_{16} (§2.2.25.3.2.2)

Appropriate procedures to validate the initial state of Register 18_{16} in regards to Register 17_{16} were previously provided in §2.7.3.2.1 for conditions where no data has been provided for Register 17_{16}. Verification of the settings of Register 18_{16} in regards to Register 17_{16} will be verified in subsequent sections as data is provided for Register 17_{16}.

2.7.3.2.3 Required Servicing of Register 18_{16} Associated with Register 18_{16} (§2.2.25.3.2.3)

Appropriate procedures to validate the initial state of Register 18_{16} in regards to Register 18_{16} were previously provided in §2.7.3.2.1 for conditions where no data has been provided for Register 18_{16}. Verification of the settings of Register 18_{16} in regards to Register 18_{16} will be verified in subsequent sections as data is provided for Register 18_{16}.

2.7.3.2.4 Required Servicing of Register 18_{16} Associated with Register 19_{16} (§2.2.25.3.2.4)

Appropriate procedures to validate the initial state of Register 18_{16} in regards to Register 19_{16} were previously provided in §2.7.3.2.1 for conditions where no data has been provided for Register 19_{16}. Verification of the settings of Register 18_{16} in regards to Register 19_{16} will be verified in subsequent sections as data is provided for Register 19_{16}.

2.7.3.2.5 Required Servicing of Register 18_{16} Associated with Register 20_{16} (§2.2.25.3.2.5)

Appropriate procedures to validate the initial state of Register 18_{16} in regards to Register 20_{16} were previously provided in §2.7.3.2.1 for conditions where no data has been provided for Register 20_{16}. Verification of the settings of Register 18_{16} in regards to Register 20_{16} will be verified in subsequent sections as data is provided for Register 20_{16}. Likewise, settings of Register 18_{16} in regards to Register 20_{16} were previously verified during ELS testing in §2.6.

2.7.3.2.6 Required Servicing of Register 18_{16} Associated with Optional Register 21_{16} (§2.2.25.3.2.6)

Appropriate procedures to validate the initial state of Register 18_{16} in regards to Optional Register 21_{16} were previously provided in §2.7.3.2.1 for conditions where no data has been provided for Register 21_{16}. Verification of the settings of Register 18_{16} in regards to Optional Register 21_{16} will be verified in subsequent sections as data is provided for Register 21_{16}. Likewise, settings of Register 18_{16} in regards to Optional Register 21_{16} were previously verified during ELS testing in §2.6.

2.7.3.2.7 Required Servicing of Register 19_{16} Associated with Register 40_{16} (§2.2.25.3.2.7)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services Capability Report.

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 19_{16}.

2.7.3.2.8 Required Servicing of Register 19_{16} Associated with Register 50_{16} (§2.2.25.3.2.8)

Appropriate procedures to validate the initial state of Register 19_{16} in regards to Register 50_{16} were previously provided in §2.7.3.2.7 for conditions where no data has been provided for Register 50_{16}. Verification of the settings of Register 19_{16} in regards to Register 50_{16} will be verified in subsequent sections as data is provided for Register 50_{16}.

2.7.3.2.9 Required Servicing of Register 19_{16} Associated with Optional Register $5F_{16}$ (§2.2.25.3.2.9)

Appropriate procedures to validate the initial state of Register 19_{16} in regards to Optional Register $5F_{16}$ were previously provided in §2.7.3.2.7 for conditions where no data has been provided for Optional Register $5F_{16}$. Verification of the settings of Register 19_{16} in regards to Optional Register $5F_{16}$ will be verified in subsequent sections as data is provided for Optional Register $5F_{16}$.

2.7.3.2.10 Required Servicing of Register 19_{16} Associated with Register 60_{16} (§2.2.25.3.2.10)

Appropriate procedures to validate the initial state of Register 19_{16} in regards to Register 60_{16} were previously provided in §2.7.3.2.7 for conditions where no data has been provided for Register 60_{16}. Verification of the settings of Register 19_{16} in regards to Register 60_{16} will be verified in subsequent sections as data is provided for Register 60_{16}.

2.7.3.3 Maximum Update Interval of Registers 18_{16} to $1C_{16}$ (§2.2.25.3.3)

No direct test procedure is required at this time as EHS data has yet to be provided to the transponder. Appropriate update checks are made in subsequent sections as data is provided.

2.7.4 Register $1D_{16}$ to $1F_{16}$ Mode S Specific Services MSP Capability (§2.2.25.4)

Introduction:

The intent of this test procedure is to validate that the transponder properly replies to GICB Extraction Interrogations (e.g., requests) for Register $1D_{16}$ through Register $1F_{16}$.

2.7.4.1 Register $1D_{16}$ Mode S Specific Services MSP Capability (§2.2.25.4)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1D_{16}$ Mode S Specific Services Capability Report.

REGISTER $1D_{16}$ MODE S SPECIFIC SERVICES MSP CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**D**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the “MB” field) set to ZERO (0) to indicate NO Capability has been established to service the Mode S Specific Services (MSP channel) designated in Register $1D_{16}$.

2.7.4.2 Register $1E_{16}$ Mode S Specific Services MSP Capability (§2.2.25.4)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1E_{16}$ Mode S Specific Services Capability Report.

REGISTER $1E_{16}$ MODE S SPECIFIC SERVICES MSP CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**E**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the Mode S Specific Services (MSP channel) designated in Register $1E_{16}$.

2.7.4.3 Register $1F_{16}$ Mode S Specific Services MSP Capability (§2.2.25.4)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1F_{16}$ Mode S Specific Services Capability Report.

REGISTER $1F_{16}$ MODE S SPECIFIC SERVICES MSP CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the Mode S Specific Services (MSP channel) designated in Register $1F_{16}$.

Note: *Up to this point, the EHS Test Procedures have been written sequentially so as to align with the sequence of the requirements given in §2.2.25. This was possible up to this point as NO ELS or EHS data has been provided to the unit under test. Once data is being provided to the unit under test, the changing of the data drives changes into multiple registers at virtually the same time. This presents a problem in attempting to develop test procedures that sequentially track the requirements which have been stated on a register basis as opposed to a functional basis. Therefore, the remainder of the ELS Test Procedures are developed on a functional basis with traceability to the requirements in §2.2.25 indicated in the procedures as appropriate.*

2.7.5 Register 40_{16} – Selected Vertical Intention (§2.2.25.5)

No test procedure is required for this section.

2.7.5.1 Part 1 – Register 40_{16} and Register $5F_{16}$ Initial Conditions (§2.2.25.5 and §2.2.25.7)

Note: *The primary purpose of the following initial procedure is to verify that Register 40_{16} and Register $5F_{16}$ are set to ALL ZERO as no capability has been established.*

a. **Register 40_{16} Initial Setting—Part a:** (§2.2.25.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16}.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	20 (14 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 ("BDS" subfield (bits 1 - 56 of the "MB" field)] set to ALL ZERO (0).

b. **Register 40_{16} Initial Setting—Part B:** (§2.2.25.5)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16}.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with the same content as required in §2.7.5.a.

Note: *Two separate interrogations are used as Register 40_{16} can be extracted by using either the Data Source or Extended Data Source extraction protocols.*

c. **Register $5F_{16}$ Initial Setting:** (§2.2.25.7)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$.

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to ZERO (0) to indicate NO Capability has been established to service the parameters designated in Register $5F_{16}$.

2.7.5.2 Part 2 – Register 40_{16} - Selected Vertical Intention Validation (§2.2.25 through §2.2.25.5)

Notes:

1. *The primary intent of Part 2 beyond data validation in Register 40_{16} is to validate capability declaration, initiation of the Comm-B Broadcast because of initial Register 40_{16} servicing, and that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts Selected in Register $5F_{16}$ go to "01".*
2. *Review all subparagraphs of Part 2 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, provide the transponder with the following Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate Mode Control Panel Selected Altitude data.

MCP / FCU Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 36669	0__1000 1111 0011 1101	+ 36672	0__100 1111 0100	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*
3. *The bit shown to the left of the underscore represents the arithmetic sign bit.*

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, provide the transponder with the following FMS Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate FMS Selected Altitude data.

Flight Management System (FMS) Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 32250	0__0111 1111 1011 1110	+ 32256	0__0111 1110 0000	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, provide the transponder with the following Barometric Pressure Setting data at a minimum rate of 5 per second in order to provide appropriate Barometric Pressure Setting data.

Air Data System (ADS) Barometric Pressure Setting Input Data		
[See Note 1]		**[See Note 2]**
Data Value (millibars)	**Typical Binary Coded Decimal (BCD) Encoding**	**Input Encoding**
+ 1209.5	001 0010 0000 1001 0101	1111 1111 1111

Notes:

1. *Data Input Value and Typical Binary Coded Decimal (BCD) Encoding represent the data as it is provided to the transponder.*
2. *Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

Barometric Correction Encoding Derivation		
12095/2 = 6047_1	94/2 = 47_0	0010 1111 0011 1111 Hex == 2F3F Hex == 12095 Decimal
6047/2 = 3023_1	47/2 = 23_1	1110 0000 1100 0000 Hex == E0C0 Hex == -8000 millibars
3023/2 = 1511_1	23/2 = 11_1	0000 1111 1111 1111 Hex == 0FFF Hex == 4095 Decimal
1511/2 = 755_1	11/2 = 5_1	
755/2 = 377_1	5/2 = 2_1	**Map Bits 28 through 40 of Register 40_{16} as:** 1111 1111 1111
377/2 = 188_1	2/2 = 1_0	
188/2 = 94_0	½ = 0_1	

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, provide the transponder with appropriate information with which to set the FMS Vertical Mode Bits as indicated in the following table:

FMS Vertical Mode Bits Input Data				
FMS Vertical Mode Bits	**Status of MCP / FCU Mode Bits**	**VNAV Mode**	**Altitude Hold Mode**	**Approach Mode**
Register 40_{16} "MB" Field Bit	48	49	50	51
Input Bit or State Setting (See Note 1)	1	0	0	0

Notes:

1. *For bit 48, "0" indicates that no mode information is being provided with which to set bits 49 through 51, and "1" indicates that mode information is being provided with which to set bits 49 through 51. For bits 49 through 51, "0" indicates that the mode is "Not Active", and "1" indicates that the mode is "Active".*
2. *When No FMS Vertical Mode Bit information is provided to the transponder, it is expected that bits 48 through 51 will be set to "0".*

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, provide the transponder with appropriate information with which to set the Target Altitude Bits as indicated in the following table:

Target Altitude Bits Input Data			
Target Altitude Bits	**Status of Target Altitude Source Bits**	**Target Altitude Source MSB**	**Target Altitude Source LSB**
Register 40_{16} "MB" Field Bits	**54**	**55**	**56**
Input Bit or State Setting (See Note 1)	1	0	0

Notes:

1. *For bit 54, "0" indicates that no information is being provided with which to set bits 55 and 56, and "1" indicates that information is being provided with which to set bits 55 and 56. For bits 55 and 56, "00" indicates that the target altitude source is Unknown.*
2. *When No Target Altitude Bit information is provided to the transponder, it is expected that bits 54 through 56 will be set to "0".*

b. **Register 40_{16} Capability Verification:** (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} – Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 40_{16} changing. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the “DF”=20 reply “MB” field provides Selected Vertical Intention Data as follows:

Part 2.b.(3) DF = 20, Selected Vertical Intention ”MB” Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
“MB” Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	1	1000 1111 0100	1	0111 1110 0000	1	1111 1111 1111	00000000	1	0	0	0	00	1	00

c. **<u>Quasi-Static Parameter Monitoring, Register 5F$_{16}$:</u>** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 2.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 5F$_{16}$ Quasi-Static Parameter Monitoring Capability.

REGISTER 5F$_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the “MB” field) are set to “01” respectively to indicate that the Selected Altitude parameter in Register 40$_{16}$ has changed.

(2). Bits 55 and 56 (bits 23 and 24 of the “MB” field) are set to “01” respectively to indicate that the FMS Selected Altitude parameter in Register 40$_{16}$ has changed.

(3). Bits 57 and 58 (bits 25 and 26 of the “MB” field) are set to “01” respectively to indicate that the Barometric Pressure Setting parameter in Register 40$_{16}$ has changed.

(4). Bits 49 and 50 (bits 17 and 18 of the “MB” field) are set to “01” respectively to indicate that the FMS Vertical Mode Bits in Register 40$_{16}$ have changed.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 2.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established and that data is valid.

(2). Bit 55 (bit 23 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 2.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 2.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established.

(2). Bit 50 (bit 18 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 2.b.(2), e.g., the “B” Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability.

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ONE (1) to indicate that Register 17_{16} is being serviced or has changed.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 2. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 2.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 2.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.3 Part 3 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 2 (§2.2.25 through §2.2.25.5)

Notes:

1. *The primary intent of Part 3 beyond data validation in Register 40_{16} is to validate that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts in Register $5F_{16}$ go to "10".*
2. *Review all subparagraphs of Part 3 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Parameter Data Input Change:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, provide the transponder with the following Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate Mode Control Panel Selected Altitude data.

MCP / FCU Selected Altitude Input Data				
[See Note 1]		[See Note 2]		
Data Value (feet)	Typical Binary Encoding	Rounded Input Data Value (feet)	Rounded Input Encoding	Knob -in- Motion
+ 24252	0__0101 1110 1011 1100	+ 24256	0__ 0101 1110 1100	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, provide the transponder with the following FMS Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate FMS Selected Altitude data.

Flight Management System (FMS) Selected Altitude Input Data				
[See Note 1]		[See Note 2]		
Data Value (feet)	Typical Binary Encoding	Rounded Input Data Value (feet)	Rounded Input Encoding	Knob -in- Motion
+ 24252	0__0101 1110 1011 1100	+ 24256	0__ 0101 1110 1100	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, provide the transponder with the following Barometric Pressure Setting data at a minimum rate of 5 per second in order to provide appropriate Barometric Pressure Setting data.

Air Data System (ADS) Barometric Pressure Setting Input Data		
[See Note 1]		[See Note 2]
Data Value (millibars)	Typical Binary Coded Decimal (BCD) Encoding	Input Encoding
+ 799.5	000 0111 1001 1001 0101	0000 0000 0000

Notes:

1. *Data Input Value and Typical Binary Coded Decimal (BCD) Encoding represent the data as it is provided to the transponder.*
2. *Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

Barometric Correction Encoding Derivation		
7995/2 = 3997_1 3997/2 = 1998_1 1998/2 = 999_0 999/2 = 499_1 499/2 = 249_1 249/2 = 124_1 124/2 = 62_0	62/2 = 31_0 31/2 = 15_1 15/2 = 7_1 7/2 = 3_1 3/2 = 1_1 1/2 = 0_1	0001 1111 0011 1011 Hex == 1F3B Hex == 7995 Decimal 1110 0000 1100 0000 Hex == E0C0 Hex == -8000 millibars 1111 1111 1111 1011 Hex == FFFB Hex == - 5 Decimal 0000 0000 0000 0100 0000 0000 0000 0001 0000 0000 0000 0101 Result is Negative: therefore, the input data is invalid. **Map Bits 28 through 40 of Register 40_{16} as: 0000 0000 0000**

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, provide the transponder with appropriate information with which to set the FMS Vertical Mode Bits as indicated in the following table:

FMS Vertical Mode Bits Input Data				
FMS Vertical Mode Bits	**Status of MCP / FCU Mode Bits**	**VNAV Mode**	**Altitude Hold Mode**	**Approach Mode**
Register 40_{16} "MB" Field Bit	48	49	50	51
Input Bit or State Setting (See Note 1)	1	1	0	1

Notes:

1. *For bit 48, "0" indicates that no mode information is being provided with which to set bits 49 through 51, and "1" indicates that mode information is being provided with which to set bits 49 through 51. For bits 49 through 51, "0" indicates that the mode is "Not Active", and "1" indicates that the mode is "Active".*
2. *When No FMS Vertical Mode Bit information is provided to the transponder, it is expected that bits 48 through 51 will be set to "0".*

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, provide the transponder with appropriate information with which to set the Target Altitude Bits as indicated in the following table:

Target Altitude Bits Input Data			
Target Altitude Bits	**Status of Target Altitude Source Bits**	**Target Altitude Source MSB**	**Target Altitude Source LSB**
Register 40_{16} "MB" Field Bits	**54**	**55**	**56**
Input Bit or State Setting (See Note 1)	1	0	1

Notes:

1. *For bit 54, "0" indicates that no information is being provided with which to set bits 55 and 56, and "1" indicates that information is being provided with which to set bits 55 and 56. For bits 55 and 56, "01" indicates that the target altitude source is Aircraft Altitude.*
2. *When No Target Altitude Bit information is provided to the transponder, it is expected that bits 54 through 56 will be set to "0".*

b. **Register 40_{16} Validation:** (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of changing the Selected Altitude data source in Part 3.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} Selected Vertical Intention Data:

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data as follows:

Part 3.b.(1) DF = 20, Selected Vertical Intention "MB" Field																
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	1	0101 1110 1100	1	0101 1110 1100	0	0000 0000 0000	00000000	1	1	0	1	00	1	01

c. **<u>Quasi-Static Parameter Monitoring, Register 5F$_{16}$:</u>** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "10" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "10" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "10" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "10" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established and that data is valid.

(2). Bit 55 (bit 23 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.c, Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established.

2.7.5.4 Part 4 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 3 (§2.2.25 through §2.2.25.5)

Notes:

1. *The primary intent of Part 4 beyond data validation in Register 40_{16} is to validate that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts in Register $5F_{16}$ go to "11".*
2. *Review all subparagraphs of Part 4 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Selected Altitude and Barometric Pressure Change:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, provide the transponder with the following Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate Mode Control Panel Selected Altitude data.

MCP / FCU Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 28666	0__0110 1111 1111 1010	+ 24672	0__0111 0000 0000	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, provide the transponder with the following FMS Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate FMS Selected Altitude data.

Flight Management System (FMS) Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 28666	0__0110 1111 1111 1010	+ 28672	0__0111 0000 0000	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(3). ADS input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, provide the transponder with the following Barometric Pressure Setting data at a minimum rate of 5 per second in order to provide appropriate Barometric Pressure Setting data.

Air Data System (ADS) Barometric Pressure Setting Input Data		
[See Note 1]		**[See Note 2]**
Data Value (millibars)	**Typical Binary Coded Decimal (BCD) Encoding**	**Input Encoding**
+ 942.7	000 1001 0100 0010 0111	0101 1001 0011

Notes:

1. *Data Input Value and Typical Binary Coded Decimal (BCD) Encoding represent the data as it is provided to the transponder.*
2. *Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

Barometric Correction Encoding Derivation		
9427/2 = 4713_1	73/2 = 36_1	0010 0100 1101 0011 Hex == 24D3 Hex == 9427 Decimal
4713/2 = 2356_1	36/2 = 18_0	1110 0000 1100 0000 Hex == E0C0 Hex == -8000 millibars
2356/2 = 1178_0	18/2 = 9_0	0000 0101 1001 0011 Hex == 0593 Hex == 1427 Decimal
1178/2 = 589_0	9/2 = 4_1	
589/2 = 294_1	4/2 = 2_0	**Map Bits 28 through 40 of Register 40_{16} as: 0101 1001 0011**
294/2 = 147_0	2/2 = 1_0	
147/2 = 73_1	1/2 = 0_1	

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, provide the transponder with appropriate information with which to set the FMS Vertical Mode Bits as indicated in the following table:

FMS Vertical Mode Bits Input Data				
FMS Vertical Mode Bits	**Status of MCP / FCU Mode Bits**	**VNAV Mode**	**Altitude Hold Mode**	**Approach Mode**
Register 40_{16} "MB" Field Bit	48	49	50	51
Input Bit or State Setting (See Note 1)	1	0	1	0

Notes:

1. *For bit 48, "0" indicates that no mode information is being provided with which to set bits 49 through 51, and "1" indicates that mode information is being provided with which to set bits 49 through 51. For bits 49 through 51, "0" indicates that the mode is "Not Active", and "1" indicates that the mode is "Active".*
2. *When No FMS Vertical Mode Bit information is provided to the transponder, it is expected that bits 48 through 51 will be set to "0".*

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, provide the transponder with appropriate information with which to set the Target Altitude Bits as indicated in the following table:

Target Altitude Bits Input Data			
Target Altitude Bits	**Status of Target Altitude Source Bits**	**Target Altitude Source MSB**	**Target Altitude Source LSB**
Register 40_{16} "MB" Field Bits	**54**	**55**	**56**
Input Bit or State Setting (See Note 1)	1	1	0

Notes:

1. *For bit 54, "0" indicates that no information is being provided with which to set bits 55 and 56, and "1" indicates that information is being provided with which to set bits 55 and 56. For bits 55 and 56, "10" indicates that the target altitude source is MCP / FCU Selected Altitude.*
2. *When No Target Altitude Bit information is provided to the transponder, it is expected that bits 54 through 56 will be set to "0".*

b. **Register 40_{16} Validation:** (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) of changing the Selected Altitude data source in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} Selected Vertical Intention Data:

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data as follows:

Part 4.b.(1) DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	1	0111 0000 0000	1	0111 0000 0000	1	0101 1001 0011	00000000	1	0	1	0	00	1	10

c. **<u>Quasi-Static Parameter Monitoring, Register $5F_{16}$:</u>** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 4.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "11" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "11" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "11" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "11" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed.

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 4.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report.

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established and that data is valid.

(2). Bit 55 (bit 23 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 4.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 4.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established.

2.7.5.5 Part 5 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 4 (§2.2.25 through §2.2.25.5)

Notes:

1. *The primary intent of Part 5 beyond data validation in Register 40_{16} is to validate that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts in Register $5F_{16}$ go to "01" as opposed to "00".*
2. *Review all subparagraphs of Part 5 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, provide the transponder with the following Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate Mode Control Panel Selected Altitude data.

MCP / FCU Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 32250	0__0111 1101 1111 0101	+ 32256	0__0111 1110 0000	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, provide the transponder with the following FMS Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate FMS Selected Altitude data.

Flight Management System (FMS) Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in- Motion**
+ 36669	0__1000 1111 0011 1101	+ 36672	0__ 1000 1111 0100	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(3). <u>Air Data System (ADS) Input of Barometric Pressure Setting:</u> (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, provide the transponder with the following Barometric Pressure Setting data at a minimum rate of 5 per second in order to provide appropriate Barometric Pressure Setting data.

Air Data System (ADS) Barometric Pressure Setting Input Data		
[See Note 1]		**[See Note 2]**
Data Value (millibars)	**Typical Binary Coded Decimal (BCD) Encoding**	**Input Encoding**
+ 1209.5	001 0010 0000 1001 0101	1111 1111 1111

Notes:

1. *Data Input Value and Typical Binary Coded Decimal (BCD) Encoding represent the data as it is provided to the transponder.*
2. *Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

Barometric Correction Encoding Derivation		
12095/2 = 6047_1	94/2 = 47_0	0010 1111 0011 1111 Hex == 2F3F Hex == 12095 Decimal
6047/2 = 3023_1	47/2 = 23_1	<u>1110 0000 1100 0000</u> Hex == <u>E0C0</u> Hex == <u>-8000</u> millibars
3023/2 = 1511_1	23/2 = 11_1	0000 1111 1111 1111 Hex == 0FFF Hex == 4095 Decimal
1511/2 = 755_1	11/2 = 5_1	
755/2 = 377_1	5/2 = 2_1	**Map Bits 28 through 40 of Register 40_{16} as:** 1111 1111 1111
377/2 = 188_1	2/2 = 1_0	
188/2 = 94_0	1/2 = 0_1	

(4). <u>FMS Vertical Mode Bits:</u> (§2.2.25.5.2.4)

Via the appropriate interface, provide the transponder with appropriate information with which to set the FMS Vertical Mode Bits as indicated in the following table:

FMS Vertical Mode Bits Input Data				
FMS Vertical Mode Bits	**Status of MCP / FCU Mode Bits**	**VNAV Mode**	**Altitude Hold Mode**	**Approach Mode**
Register 40_{16} "MB" Field Bit	48	49	50	51
Input Bit or State Setting (See Note 1)	1	1	1	0

Notes:

1. *For bit 48, "0" indicates that no mode information is being provided with which to set bits 49 through 51, and "1" indicates that mode information is being provided with which to set bits 49 through 51. For bits 49 through 51, "0" indicates that the mode is "Not Active", and "1" indicates that the mode is "Active".*
2. *When No FMS Vertical Mode Bit information is provided to the transponder, it is expected that bits 48 through 51 will be set to "0".*

(5). <u>Target Altitude Bits:</u> (§2.2.25.5.2.6)

Via the appropriate interface, provide the transponder with appropriate information with which to set the Target Altitude Bits as indicated in the following table:

Target Altitude Bits Input Data			
Target Altitude Bits	**Status of Target Altitude Source Bits**	**Target Altitude Source MSB**	**Target Altitude Source LSB**
Register 40_{16} "MB" Field Bits	**54**	**55**	**56**
Input Bit or State Setting (See Note 1)	1	1	1

Notes:

1. *For bit 54, "0" indicates that no information is being provided with which to set bits 55 and 56, and "1" indicates that information is being provided with which to set bits 55 and 56. For bits 55 and 56, "11" indicates that the target altitude source is FMS Selected Altitude.*
2. *When No Target Altitude Bit information is provided to the transponder, it is expected that bits 54 through 56 will be set to "0".*

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 5.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data as follows:

Part 5.b.(1) DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	1	0111 1110 0000	1	1000 1111 0100	1	1111 1111 1111	00000000	1	1	1	0	00	1	11

c. **Quasi-Static Parameter Monitoring, Register $5F_{16}$:** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 5.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "01" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "01" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "01" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "01" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed.

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 5.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established and that data is valid.

(2). Bit 55 (bit 23 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 5.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 5.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established.

2.7.5.6 Part 6 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 5 (§2.2.25 through §2.2.25.5)

Notes:

1. *The primary intent of Part 6 beyond data validation in Register 40_{16} is to validate that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts in Register $5F_{16}$ go to "00" as parameter data input has been terminated.*
2. *Review all subparagraphs of Part 6 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, terminate provision of valid data to the transponder with Selected Altitude data.

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, terminate provision of valid data to the transponder with FMS Selected Altitude data.

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, terminate provision of valid data to the transponder with the Barometric Pressure Setting data.

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, terminate provision of valid data to the transponder with which to set the FMS Vertical Mode Bits.

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, terminate provision of valid data to the transponder with which to set the Target Altitude Bits.

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the "DR" Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data with:

Part 6.b. DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	0	0000 0000 0000	0	0000 0000 0000	0	0000 0000 0000	00000000	0	0	0	0	00	0	00

c. **<u>Quasi-Static Parameter Monitoring, Register $5F_{16}$:</u>** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 6.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "00" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "00" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "00" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed as data input has been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "00" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed as data input has been terminated.

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "0" to indicate that Register 40_{16} servicing capability has been lost and that data is NOT VALID.

(2). Bit 55 (bit 23 of the "MB" field) set to "0" to indicate that Register $5F_{16}$ servicing capability has been terminated because of loss of data.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within **FIVE** (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 6.b.(2), e.g., the "B" Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ZERO (0) to indicate that the transponder has lost Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability.

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ZERO (0) to indicate that Register 17_{16} has changed as Register 40_{16} data has been lost.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 6. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 2.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 6.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.7 Part 7 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 6 (§2.2.25 through §2.2.25.5)

Notes:

1. *The intent of Part 7 is to demonstrate that servicing of Register 40_{16} can be initiated by insertion of a single parameter, e.g., MCP Selected Altitude data. Part 7 also validates that Selected Altitude Count in Register $5F_{16}$ goes to "01" as the count should restart after having had a data termination.*
2. *Review all subparagraphs of Part 7 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, provide the transponder with the following Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate Mode Control Panel Selected Altitude data.

MCP / FCU Selected Altitude Input Data				
[See Note 1]		[See Note 2]		
Data Value (feet)	Typical Binary Encoding	Rounded Input Data Value (feet)	Rounded Input Encoding	Knob -in- Motion
+ 21845	0__0101 0101 0101 0101	+ 21840	0__0101 0101 0101	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Continue to NOT provide FMS Selected Altitude data as established in Part 6.a.(2).

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Continue to NOT provide Barometric Pressure Setting data as established in Part 6.a.(3).

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Continue to NOT provide FMS Vertical Mode Bit data as established in Part 6.a.(4).

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 7.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the “B” timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the “DR” Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the “DR” field. If the “DR” field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the “DR” field changes, start a Test Timer to monitor that the “B”-Timer runs for 18 ±1.0 seconds.

“DR” = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply “MB” field provides Selected Vertical Intention Data with:

Part 7.b. DF = 20, Selected Vertical Intention ”MB” Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
“MB” Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	1	0101 0101 0101	0	0000 0000 0000	0	0000 0000 0000	00000000	0	0	0	0	00	0	00

c. **Quasi-Static Parameter Monitoring, Register $5F_{16}$:** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 7.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "01" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed as data input was restarted after having been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "00" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "00" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed as data input has been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "00" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed as data input has been terminated.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 7.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established as new data has been provided.

(2). Bit 55 (bit 23 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 7.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 7.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 7.b.(2), e.g., the "B" Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has restored Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability.

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ONE (1) to indicate that Register 17_{16} has changed as Register 40_{16} data has been restored.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 7. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 7.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 7.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.8 Part 8 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 7 (§2.2.25 through §2.2.25.5)

Repeat ALL of Part 6 (see §2.7.5.6).

2.7.5.9 Part 9 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 8 (§2.2.25 through §2.2.25.5)

<u>Notes:</u>

1. *The intent of Part 9 is to demonstrate that servicing of Register 40_{16} can be initiated by insertion of a single parameter, e.g., FMS Selected Altitude data. Part 9 also validates that FMS Selected Altitude Count in Register $5F_{16}$ goes to "01" as the count should restart after having had a data termination.*
2. *Review all subparagraphs of Part 9 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data Input Initialization:</u>** (§2.2.25.5.1 and §2.2.25.5.2)

(1). <u>Mode Control Panel Selected Altitude:</u> (§2.2.25.5.2.1)

Continue to NOT provide MCP Selected Altitude data as established in Part 8 (e.g., Part 6.a.(1)).

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, provide the transponder with the following FMS Selected Altitude data at a minimum rate of 5 per second in order to provide appropriate FMS Selected Altitude data.

Flight Management System (FMS) Selected Altitude Input Data				
[See Note 1]		**[See Note 2]**		
Data Value (feet)	**Typical Binary Encoding**	**Rounded Input Data Value (feet)**	**Rounded Input Encoding**	**Knob -in-Motion**
+ 36669	0__1000 1111 0011 1101	+ 36672	0__ 1000 1111 0100	NO

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 40_{16}.*

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Continue to NOT provide Barometric Pressure Setting data as established in Part 8 (e.g., Part 6.a.(3)).

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Continue to NOT provide FMS Vertical Mode Bit data as established in Part 8 (e.g., Part 6.a.(4)).

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 9.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} – Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the "DR" Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data with:

Part 9.b. DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	0	0000 0000 0000	1	1000 1111 0100	0	0000 0000 0000	00000000	0	0	0	0	00	0	00

c. **<u>Quasi-Static Parameter Monitoring, Register 5F$_{16}$:</u>** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 9.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 5F$_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER 5F$_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "00" respectively to indicate that the Selected Altitude parameter in Register 40$_{16}$ has changed as data input has been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "01" respectively to indicate that the FMS Selected Altitude parameter in Register 40$_{16}$ has changed as data input was restarted after having been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "00" respectively to indicate that the Barometric Pressure Setting parameter in Register 40$_{16}$ has changed as data input has been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "00" respectively to indicate that the FMS Vertical Mode Bits in Register 40$_{16}$ have changed as data input has been terminated.

d. **<u>Common Usage GICB Capability Report, Register 17$_{16}$:</u>** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 9.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17$_{16}$ Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established as new data has been provided.

(2). Bit 55 (bit 23 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 9.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 9.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 9.b.(2), e.g., the "B" Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has restored Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability.

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ONE (1) to indicate that Register 17_{16} has changed as Register 40_{16} data has been restored.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 9. g. (e.g., the last step) until the transponder replies with a DF=20 reply with “DR” NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 9.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the “B” timer started in Part 9.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.10 Part 10 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 9 (§2.2.25 through §2.2.25.5)

Repeat ALL of Part 6 (see §2.7.5.6).

2.7.5.11 Part 11 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 10 (§2.2.25 through §2.2.25.5)

<u>Notes:</u>

1. *The intent of Part 11 is to demonstrate that servicing of Register 40_{16} can be initiated by insertion of a single parameter, e.g., Barometric Pressure Setting data. Part 11 also validates that the Barometric Pressure Setting Count in Register $5F_{16}$ goes to “01” as the count should restart after having had a data termination.*
2. *Review all subparagraphs of Part 11 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data Input Initialization:</u>** (§2.2.25.5.1 and §2.2.25.5.2)

(1). <u>Mode Control Panel Selected Altitude:</u> (§2.2.25.5.2.1)

Continue to NOT provide MCP Selected Altitude data as established in Part 10 (e.g., Part 6.a.(1)).

(2). <u>Flight Management System (FMS) Selected Altitude:</u> (§2.2.25.5.2.2)

Continue to NOT provide FMS Selected Altitude data as established in Part 10 (e.g., Part 6.a.(2)).

(3). <u>Air Data System (ADS) input of Barometric Pressure Setting:</u> (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, provide the transponder with the following Barometric Pressure Setting data at a minimum rate of 5 per second in order to provide appropriate Barometric Pressure Setting data.

Air Data System (ADS) Barometric Pressure Setting Input Data		
[See Note 1]		**[See Note 2]**
Data Value (millibars)	**Typical Binary Coded Decimal (BCD) Encoding**	**Input Encoding**
+ 942.7	000 1001 0100 0010 0111	0101 1001 0011

<u>Notes:</u>

1. *Data Input Value and Typical Binary Coded Decimal (BCD) Encoding represent the data as it is provided to the transponder.*
2. *Input Encoding represent the data as it is expected to be seen in the “MB” field of Register 40_{16}.*

Barometric Correction Encoding Derivation		
9427/2 = 4713_1 4713/2 = 2356_1 2356/2 = 1178_0 1178/2 = 589_0 589/2 = 294_1 294/2 = 147_0 147/2 = 73_1	73/2 = 36_1 36/2 = 18_0 18/2 = 9_0 9/2 = 4_1 4/2 = 2_0 2/2 = 1_0 1/2 = 0_1	0010 0100 1101 0011 Hex == 24D3 Hex == 9427 Decimal 1110 0000 1100 0000 Hex == E0C0 Hex == -8000 millibars 0000 0101 1001 0011 Hex == 0593 Hex == 1427 Decimal **Map Bits 28 through 40 of Register 40_{16} as: 0101 1001 0011**

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Continue to NOT provide FMS Vertical Mode Bit data as established in Part 10 (e.g., Part 6.a.(4)).

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 11.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} – Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	"PC" =	"RR" =	"DI" =	"IIS" =	"RRS =	"X" =	"LOS" =	"XX" =	"TMS" =
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the "DR" Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data with:

Part 11.b. DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	0	0000 0000 0000	0	0000 0000 0000	1	0101 1001 0011	00000000	0	0	0	0	00	0	00

c. **Quasi-Static Parameter Monitoring, Register $5F_{16}$:** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 11.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the “MB” field) are set to “00” respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the “MB” field) are set to “00” respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the “MB” field) are set to “01” respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed as data input was restarted after having been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the “MB” field) are set to “00” respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed as data input has been terminated.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 11.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established as new data has been provided.

(2). Bit 55 (bit 23 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 11.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 11.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the "MB" field) set to "1" to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the "MB" field) set to "1" to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 11.b.(2), e.g., the "B" Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has restored Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability,

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ONE (1) to indicate that Register 17_{16} has changed as Register 40_{16} data has been restored.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 11. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 11.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 11.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.12 Part 12 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 11 (§2.2.25 through §2.2.25.5)

Repeat ALL of Part 6 (see §2.7.5.6).

2.7.5.13 Part 13 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 12 (§2.2.25 through §2.2.25.5)

Notes:

1. *The intent of Part 13 is to demonstrate that servicing of Register 40_{16} can also be initiated by insertion of a single parameter, e.g., FMS Vertical Mode Bit data. Part 13 also validates that the FMS Vertical Mode Count in Register $5F_{16}$ goes to "01" as the count should restart after having had a data termination.*
2. *Review all subparagraphs of Part 13 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Continue to NOT provide MCP Selected Altitude data as established in Part 12 (e.g., Part 6.a.(2)).

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Continue to NOT provide FMS Selected Altitude data as established in Part 12 (e.g., Part 6.a.(3)).

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Continue to NOT provide Barometric Pressure Setting data as established in Part 12 (e.g., Part 6.a.(3)).

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, provide the transponder with appropriate information with which to set the FMS Vertical Mode Bits as indicated in the following table:

FMS Vertical Mode Bits Input Data				
FMS Vertical Mode Bits	**Status of MCP / FCU Mode Bits**	**VNAV Mode**	**Altitude Hold Mode**	**Approach Mode**
Register 40_{16} "MB" Field Bit	48	49	50	51
Input Bit or State Setting (See Note 1)	1	0	1	0

Notes:
1. *For bit 48, "0" indicates that no mode information is being provided with which to set bits 49 through 51, and "1" indicates that mode information is being provided with which to set bits 49 through 51. For bits 49 through 51, "0" indicates that the mode is "Not Active", and "1" indicates that the mode is "Active".*
2. *When No FMS Vertical Mode Bit information is provided to the transponder, it is expected that bits 48 through 51 will be set to "0".*

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 13.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the "DR" Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data with:

Part 13.b. DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	0	0000 0000 0000	0	0000 0000 0000	0	0000 0000 0000	00000000	1	0	1	0	00	0	00

c. **Quasi-Static Parameter Monitoring, Register $5F_{16}$:** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 13.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "00" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the “MB” field) are set to “00” respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the “MB” field) are set to “00” respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed as data input has been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the “MB” field) are set to “01” respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed as data input was restarted after having been terminated.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 13.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established as new data has been provided.

(2). Bit 55 (bit 23 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established and that data is valid.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 13.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

f. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 13.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

2.7.5.14 Part 14 – Register 40_{16} - Selected Vertical Intention - Data Change Validation - Set 13 (§2.2.25 through §2.2.25.5)

<u>Note:</u> *Review all subparagraphs of Part 14 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data Input Initialization:</u>** (§2.2.25.5.1 and §2.2.25.5.2)

(1). <u>Mode Control Panel Selected Altitude:</u> (§2.2.25.5.2.1)

For each line Item # in the following table (Table 14.a(1)), provide the transponder with Mode Control Panel Selected Altitude having a value as indicated in the "Data Value" (feet) Column in the table.

Table 14.a(1): Register 40_{16} MCP/FCU Selected Altitude (ARINC label 102)						
Item #	Type of Value	Generic MCP/FCU Selected Altitude Input (BNR)		Register 40_{16} MCP/FCU Selected Altitude		
		Status	Data Value (feet)	Status (bit 1)	Decimal Value (feet)	Binary Value (bit 2 ----- 13)
1	Basic	Valid	43680.00	1	43680.00	1010 1010 1010
2	Basic	Valid	21840.00	1	21840.00	0101 0101 0101
3	Basic	Valid	30576.00	1	30576.00	0111 0111 0111
4	Basic	Valid	48048.00	1	48048.00	1011 1011 1011
5	Basic	Valid	56784.00	1	56784.00	1101 1101 1101
6	Basic	Valid	61152.00	1	61152.00	1110 1110 1110
7	Max	Valid	65530.00	1	65520.00	1111 1111 1111
8	Min	Valid	0.00	1	0.00	0000 0000 0000
9	Rounded (½ LSB)	Valid	21864.00	1	21872.00	0101 0101 0111
10	Rounded (¼ LSB)	Valid	21844.00	1	21840.00	0101 0101 0101
11	Invalid	Invalid	43680.00	0	0.00	0000 0000 0000

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

For each line Item # in the following table (Table 14.a(2)), provide the transponder with FMS Selected Altitude having a value as indicated in the "Data Value" (feet) Column in the table.

Table 14.a(2): Register 40_{16} FMS Selected Altitude (ARINC label 102)						
Item #	Type of Value	Generic FMS Selected Altitude Input (BNR)		Register 40_{16} FMS Selected Altitude		
		Status	Data Value (feet)	Status (bit 14)	Decimal Value (feet)	Binary Value (bit 15 ----- 26)
1	Basic	Valid	43680.00	1	43680.00	1010 1010 1010
2	Basic	Valid	21840.00	1	21840.00	0101 0101 0101
3	Basic	Valid	30576.00	1	30576.00	0111 0111 0111
4	Basic	Valid	48048.00	1	48048.00	1011 1011 1011
5	Basic	Valid	56784.00	1	56784.00	1101 1101 1101
6	Basic	Valid	61152.00	1	61152.00	1110 1110 1110
7	Max	Valid	65530.00	1	65520.00	1111 1111 1111
8	Min	Valid	0.00	1	0.00	0000 0000 0000
9	Rounded (½ LSB)	Valid	21864.00	1	21872.00	0101 0101 0111
10	Rounded (¼ LSB)	Valid	21844.00	1	21840.00	0101 0101 0101
11	Invalid	Invalid	43680.00	0	0.00	0000 0000 0000

(3). Air Data System (ADS) input of Barometric Correction: (§2.2.25.5.2.3)

For each line Item # in the following table (Table 14.a(3)), provide the transponder with Barometric Correction data having a value as indicated in the "Data Value" (+800 millibars) Column in the table.

Table 14.a(3) : Register 40_{16} Barometric Correction (pressure) (ARINC label 234)

Item #	Type of Value	ARINC Barometric pressure setting minus 800mb (BCD)		Register 40_{16} Barometric pressure setting minus 800mb		
		Status	Data Value +800 millibars	Status (bit 27)	Decimal Value +800 millibars	Binary Value (bit 28 ----- 39)
1	Basic	Valid	936.50	1	936.50	0101 0101 0101
2	Basic	Valid	991.10	1	991.10	0111 0111 0111
3	Max	Valid	1050	1	1050	1001 1100 0100
4	Min	Valid	800	1	0.00	0000 0000 0000
5	Invalid	Invalid	991.10	0	0.00	0000 0000 0000
6	Baro min	Valid	750	0	0	0000 0000 0000

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, terminate provision of valid data to the transponder with which to set the FMS Vertical Mode Bits.

Note: *No further test cases need be provided for FMS Vertical Mode Bit settings as sufficient cases have been demonstrated in the previous steps.*

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, terminate provision of valid data to the transponder with which to set the Target Altitude Bits.

Note: *No further test cases need be provided for Target Altitude Bit settings as sufficient cases have been demonstrated in the previous steps.*

b. **Register 40_{16} Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed for each line Item # in the tables given in Part 14.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP

1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	"PC" =	"RR" =	"DI" =	"IIS" =	"RRS =	"X" =	"LOS" =	"XX" =	"TMS" =
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). For each line Item # in Table 14.a(1) with "MB" field Status (bit 1) equivalent to that shown in the Status (bit 1) column of Table 14.a(1).

(2). For each line Item # in Table 14.a(1), with "MB" field bit 2 through 13 equivalent to that shown in the Binary Value (bit 2 - 13) column of Table 14.a(1).

(3). For each line Item # in Table 14.a(2) with “MB” field Status (bit 14) equivalent to that shown in the Status (bit 14) column of Table 14.a(2).

(4). For each line Item # in Table 14.a(2), with “MB” field bit 15 through 26 equivalent to that shown in the Binary Value (bit 15 - 26) column of Table 14.a(2).

(5). For each line Item # in Table 14.a(3) with “MB” field Status (bit 27) equivalent to that shown in the Status (bit 27) column of Table 14.a(3).

(6). For each line Item # in Table 14.a(3), with “MB” field bit 28 through 39 equivalent to that shown in the Binary Value (bit 28 - 39) column of Table 9.a(3).

Note: *Cumulative results are as shown in the following table.*

Part 14.b. DF = 20, Selected Vertical Intention ”MB” Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
“MB” Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**MCP Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
Data: / Item #	**Status**	**Data**	**Status**	**Data**	**Status**	**Data**		**Mode**	**Mode**	**Mode**	**Mode**		**Status**	**SRC**
1	1	1010 1010 1010	1	1010 1010 1010	1	0101 0101 0101	00000000	0	0	0	0	00	0	00
2	1	0101 0101 0101	1	0101 0101 0101	1	0111 0111 0111	00000000	0	0	0	0	00	0	00
3	1	0111 0111 0111	1	0111 0111 0111	1	1001 1100 0100	00000000	0	0	0	0	00	0	00
4	1	1011 1011 1011	1	1011 1011 1011	1	0000 0000 0000	00000000	0	0	0	0	00	0	00
5	1	1101 1101 1101	1	1101 1101 1101	0	0000 0000 0000	00000000	0	0	0	0	00	0	00
6	1	1110 1110 1110	1	1110 1110 1110	0	0000 0000 0000	00000000	0	0	0	0	00	0	00
7	1	1111 1111 1111	1	1111 1111 1111			00000000	0	0	0	0	00	0	00
8	1	0000 0000 0000	1	0000 0000 0000			00000000	0	0	0	0	00	0	00
9	1	0101 0101 0111	1	0101 0101 0111			00000000	0	0	0	0	00	0	00
10	1	0101 0101 0101	1	0101 0101 0101			00000000	0	0	0	0	00	0	00
11	0	0000 0000 0000	0	0000 0000 0000			00000000	0	0	0	0	00	0	00

2.7.5.15 Part 15 – Reduced Data Rate (§2.2.25.5.3)

Notes:

1. *The primary intent of Part 6 beyond data validation in Register 40_{16} is to validate that the MCP /FCU Selected Altitude, FMS Selected Altitude, Barometric Pressure Setting, and FMS Vertical Mode Bit Counts in Register $5F_{16}$ go to “00” as parameter data inputs are reduced to rates that are less than the minimum acceptable rate.*
2. *Review all subparagraphs of Part 6 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.5.1 and §2.2.25.5.2)

(1). Mode Control Panel Selected Altitude: (§2.2.25.5.2.1)

Via the appropriate Mode Control Panel (or other) interface, set the rate at which valid Selected Altitude data is provided to less than once per two seconds.

(2). Flight Management System (FMS) Selected Altitude: (§2.2.25.5.2.2)

Via the appropriate FMS (or other) interface, set the rate at which valid FMS Selected Altitude data is provided to less than once per two seconds.

(3). Air Data System (ADS) input of Barometric Pressure Setting: (§2.2.25.5.2.3)

Via the appropriate ADS (or other) interface, set the rate at which valid Barometric Pressure Setting data is provided to less than once per two seconds.

(4). FMS Vertical Mode Bits: (§2.2.25.5.2.4)

Via the appropriate interface, set the rate at which valid FMS Vertical Mode data is provided to less than once per two seconds.

(5). Target Altitude Bits: (§2.2.25.5.2.6)

Via the appropriate interface, set the rate at which valid Target Altitude data is provided to less than once per two seconds.

b. **Register 40_{16} Capability Verification**: (§2.2.25.1.4 and §2.2.25.5 through §2.2.25.5.3)

Within ONE (1) second of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 40_{16} - Selected Vertical Intention data.

REGISTER 40_{16} SELECTED VERTICAL INTENTION GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**20** (14 HEX)	**7**	0	**0**	0	0	0	0

Note: *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated because servicing of Register $5F_{16}$ capability has changed. Note that the update to Register $5F_{16}$ may take up to one minute to change the "DR" Field to declare the broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Selected Vertical Intention Data with:

Part 6.b. DF = 20, Selected Vertical Intention "MB" Field														
Reply Bits:	33	34 ------------ 45	46	47 --------------- 58	59	60 -------------- 71	72 ---- 79	80	81	82	83	84- 85	86	87 -- 88
"MB" Bits:	1	2 ------------- 13	14	15 --------------- 26	27	28 -------------- 39	40 --- 47	48	49	50	51	52 - 53	54	55 -- 56
Field:	**Selected Altitude**		**FMS Selected Altitude**		**Baro. Pressure Setting**		**RSVD**	**MCP**	**VNAV**	**A-HLD**	**APP**	**RSVD**	**Target**	**Target**
	Status	Data	Status	Data	Status	Data		Mode	Mode	Mode	Mode		Status	SRC
Data:	0	0000 0000 0000	0	0000 0000 0000	0	0000 0000 0000	00000000	0	0	0	0	00	0	00

c. **Quasi-Static Parameter Monitoring, Register $5F_{16}$:** (§2.2.25.7)

Within 0.5 seconds of completing the reply acceptance in Part 6.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $5F_{16}$ Quasi-Static Parameter Monitoring Capability:

REGISTER $5F_{16}$ QUASI-STATIC PARAMETER MONITORING GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**F**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 and 34 (bits 1 and 2 of the "MB" field) are set to "00" respectively to indicate that the Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(2). Bits 55 and 56 (bits 23 and 24 of the "MB" field) are set to "00" respectively to indicate that the FMS Selected Altitude parameter in Register 40_{16} has changed as data input has been terminated.

(3). Bits 57 and 58 (bits 25 and 26 of the "MB" field) are set to "00" respectively to indicate that the Barometric Pressure Setting parameter in Register 40_{16} has changed as data input has been terminated.

(4). Bits 49 and 50 (bits 17 and 18 of the "MB" field) are set to "00" respectively to indicate that the FMS Vertical Mode Bits in Register 40_{16} have changed as data input has been terminated.

d. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 41 (bit 9 of the "MB" field) set to "0" to indicate that Register 40_{16} servicing capability has been lost and that data is NOT VALID.

(2). Bit 55 (bit 23 of the "MB" field) set to "0" to indicate that Register $5F_{16}$ servicing capability has been terminated because of loss of data.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 6.c, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 80 (bit 49 of the “MB” field) set to “1” to indicate that Register 40_{16} servicing capability has been established during the power-on cycle.

(2). Bit 50 (bit 18 of the “MB” field) set to “1” to indicate that Register $5F_{16}$ servicing capability has been established during the power-on cycle.

g. **Broadcast Extraction, Register 10_{16}:** (§2.2.25.1 and §2.2.25.2.3)

Within less than 15 seconds after starting the Test Timer in Part 6.b.(2), e.g., the “B” Timer monitor, interrogate the transponder with the following Comm-B Extraction interrogations in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Within ONE (1) second of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The 1 second is based on the update rate specified for Register 10_{16}.*

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ZERO (0) to indicate that the transponder has lost Mode S Specific Services Capability.

(4). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to ZERO (0) to indicate that there is NO Aircraft Identification capability.

(5). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(6). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ZERO (0) to indicate that Register 17_{16} has changed as Register 40_{16} data has been lost.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1 and §2.2.25.2.3)

Continue to interrogate the transponder with the interrogation described in Part 6. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 2.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 6.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.5.16 Part 16 – Multiple Data Sources (§2.2.25 through §2.2.25.5)

If Multiple Data Sources of Register 40_{16} parameters are provided to the Unit-Under-Test (UUT), then REPEAT all applicable sections of Part 2 for each additional data source that was not tested while performing Parts 1 through 14 above.

2.7.6 Register 50_{16} Enhanced Surveillance – Protocol and Interface (§2.2.25.6)

Introduction:

The intent of this test procedure is to validate all aspects of Enhanced Surveillance Servicing of Register 50_{16}.

2.7.6.1 Part 1 – Capability Verification (§2.2.25.6)

Test Procedure:

Note: *The primary intent of Part 1 is to validate appropriate capability declaration of No Capability prior to providing data to Register 50_{16}.*

Ensure that NO Flight Identification or Aircraft Registration data is being provided to the transponder.

Ensure that the TCAS / Transponder interface is NOT ACTIVE. If the interface is active, TCAS will provide data to set the Data Link Capability and thereby compromise the results of the following tests. Likewise, TCAS could attempt to set the Resolution Advisory Report and thereby compromise the results of the following tests.

Ensure that no other data is being provided to the transponder that could result in the loading of BDS registers internal to the transponder. This includes NO Servicing of Register 40_{16}.

Disable the Extended Squitter function prior to starting the following procedures in order to keep from setting various BDS registers during the following tests.

a. **Register 50_{16} Initial Setting – Part A:** (§2.2.25.6)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} Track and Turn Report.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 --- 32
				"SD"	
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"NOT ASSIGNED"** =
4	0	21 (15 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 ("BDS" subfield (bits 1 through 56 of the "MB" field)] set to ALL ZERO (0).

b. **Register 50_{16} Initial Setting – Part B:** (§2.2.25.6)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} Track and Turn Report.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with the same content as required in section 2.7.6.1.a.

Note: *Two separate interrogations are used as Register 50_{16} can be extracted by using either the Data Source or Extended Data Source extraction protocols.*

c. **Data Link Capability Report, Register 10_{16}:** (§2.2.25.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 10_{16} Data Link Capability Report.

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**17** (11 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to "0" to indicate NO Flight Identification capability.

(2). Bit 57 [Mode S Specific Services Capability (bit 25 of the "MB" field)] set to "0" to indicate NO Mode S Specific Services Capability.

Note: *Servicing of Registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} through $1C_{16}$, 20_{16} and 30_{16} does not constitute Mode S Specific Services Capability.*

(3). Bit 67 [Surveillance Identifier ("SI") (bit 35 of the "MB" field)] set to "1" to indicate that the transponder DOES Have "SI" Capability.

(4). Bit 68 [Common Usage GICB Capability Report (bit 36 of the "MB" field)] set to "0" to indicate that there has been no change in the Common Usage GICB Capability Report, Register 17_{16}.

d. **<u>Common Usage GICB Capability Report, Register 17$_{16}$:</u>** (§2.2.25.2)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17$_{16}$ Common Usage GICB Capability Report:

REGISTER 17$_{16}$ COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 - 60 (bits 1 - 28 of the "MB" field) set to "0" to indicate NO Capability or capability changes in the Common Usage GICB Capability Report, Register 17$_{16}$.

(2). Bits 61 - 88 (bits 29 - 56 of the "MB" field) set to "0" since these bits are Reserved or "Don't Care".

e. **<u>Mode S Specific Services GICB Capability, Register 18$_{16}$:</u>** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18$_{16}$ Mode S Specific Services GICB Capability:

REGISTER 18$_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" Field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 18$_{16}$.

f. **<u>Mode S Specific Services GICB Capability, Register 19$_{16}$:</u>** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19$_{16}$ Mode S Specific Services GICB Capability:

REGISTER 19$_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register 19_{16}.

g. **Mode S Specific Services GICB Capability, Register $1A_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1A_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1A_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**A**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1A_{16}$.

h. **Mode S Specific Services GICB Capability, Register $1B_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1B_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1B_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**B**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1B_{16}$.

i. **Mode S Specific Services GICB Capability, Register $1C_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1C_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1C_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**C**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1C_{16}$.

2.7.6.2 Part 2 – Register 50_{16} - Track and Turn Report Validation (§2.2.25.6 and §2.2.25.6.1)

Notes:

1. *The primary intent of Part 2 beyond data validation in Register 50_{16} is to validate capability declaration.*
2. *Review all subparagraphs of Part 2 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, provide the transponder with the following Roll Angle data at a minimum rate of 5 per second in order to provide appropriate Roll Angle information.

Roll Angle (degrees)			
[See Note 1]		[See Note 2, 3]	
Data Value (degrees)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees)**	**Rounded Input Encoding**
+ 29.99816895	0__001 0101 0101 0101	+ 30.05859375	0_0 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = Right Wing Down, 1 = Left Wing Down*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded to a resolution of 0.17578125 degrees; therefore,
   0_001 0101 010 1 0101
   + 000 0000 000 1 0000
   0_001 0101 011 0 0101
   Register 50_{16} "MB" encoding = 0_00 1010 1011 (bits 2 through 11) (0AB Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 2 being to the left of the "Underscore".*

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, provide the transponder with the following Track Angle (True) data at a minimum rate of 5 per second in order to provide appropriate Track Angle (True) information.

Track Angle (True) (degrees)			
[See Note 1]		**[See Note 2, 3]**	
Data Value (degrees)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees)**	**Rounded Input Encoding**
+ 119.9981689	0__101 0101 0101 0101	+ 120.0585938	0_10 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = East, 1 = West.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded to a resolution of 0.17578125 degrees; therefore,
   0_101 0101 010 1 0101
   + 000 0000 000 1 0000

   0_101 0101 011 0 0101

   Register 50_{16} "MB" encoding = 0_10 1010 1011 (bits 13 through 23) (2AB Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 13 being to the left of the "Underscore".*

(3). Ground Speed: (§2.2.25.6.2.3)

Via an appropriate input interface, provide the transponder with the following Ground Speed data at a minimum rate of 5 per second in order to provide appropriate Ground Speed information.

Ground Speed (knots)			
[See Note 1]		**[See Note 2]**	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
+ 2730.625	0__101 0101 0101 0101	2046	11 1111 1111

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*
3. *Maximum Ground Speed that can be mapped into Register 50_{16} is 2046 knots. If valid input data exceeds this value, then the Register 50_{16} "MB" (bit 25 through 34) encoding should be set to ALL ONE's.*

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, provide the transponder with the following Track Angle Rate data at a minimum rate of 5 per second in order to provide appropriate Track Angle Rate information.

Track Angle Rate (degrees/second)			
[See Note 1]		**[See Note 2, 3]**	
Data Value (degrees/second)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees/second)**	**Rounded Input Encoding**
+ 21.328125	0__101 0101 0101	15.96875	0_1 1111 1111

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = Clockwise (CW) = Right, 1 = Counter-Clockwise (CCW) = Left.*
2. *The input data if +21.328125 degrees/second exceeds the maximum allowable value of 15.96875 degrees/second that can be encoded in Register 50_{16}: therefore, the data in Register 50_{16} shall be set to all ONE's with the exception of the sign bit.*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 36 being to the left of the "Underscore".*

(5). True Air Speed - ADS: (§2.2.25.6.2.5)

Via an appropriate input interface, provide the transponder with the following True Air Speed data at a minimum rate of 5 per second in order to provide appropriate True Air Speed information.

True Air Speed (knots) - ADS			
[See Note 1]		**[See Note 2]**	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
1365.3125	0__101 0101 0101 0101	1366.00	10 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*
   Data must be rounded to a resolution of 2.0 knots; therefore,
   10 1010 1010 1 0101
   + 00 0000 0000 1 0000
   10 1010 1011 0 0101
   Register 50_{16} "MB" encoding = 10 1010 1011 (bit 47 through 56) (2AB Hex)

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the “B” timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 50_{16} changing. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the “DR” field. If the “DR” field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the “DR” field changes, start a Test Timer to monitor that the “B”-Timer runs for 18 ±1.0 seconds.

“DR” = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the “DF”=20 reply “MB” field provides data with:

Part 2.b.(3) DF = 20, Track and Turn Report ”MB” Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
“MB” Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	1	0	0 1010 1011	1	0	10 1010 1011	1	11 1111 1111	1	0	1 1111 1111	1	10 1010 1011

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 48 (bit 16 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established and that data is valid.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established.

e. **<u>Mode S Specific Services GICB Capability, Register 19_{16}:</u>** (§2.2.25.3.2.8 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established.

f. **<u>Comm-B Broadcast Validation:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 2.a, verify that the "DR" field in DF=20 replies is set to DR= 4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **<u>Comm-B Broadcast Extraction:</u>** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 2.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 ["Common Usage GICB Capability Report" (bit 36 of the "MB" field)] set to ONE (1) to indicate that Register 17_{16} is being serviced or has changed.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 2. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 2.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 2.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.3 Part 3 – Register 50_{16} - Track and Turn Report - Data Change Validation (§2.2.25.6 and §2.2.25.6.1)

Notes:

1. *The primary intent of Part 3 beyond data validation in Register 50_{16} is to validate Declaration of Capability as data has been terminated.*
2. *Review all subparagraphs of Part 3 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Roll Angle data.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Track Angle data.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Ground Speed data.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Track Angle Rate data.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Airspeed data.

b. **Register 50_{16} Validation:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of changing the data sources in Part 3.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} Track and Turn Report Data:

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as data for Register 50_{16} has been terminated. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides data with:

Part 3.b.(3) DF = 20, Track and Turn Report "MB" Field													
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	0	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	00 0000 0000

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 48 (bit 16 of the "MB" field) set to "0" to indicate that Register 50_{16} servicing capability has been changed as data for Register 50_{16} has been terminated.

d. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3 and §2.2.25.3.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the “DR” field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS”** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 3.a, verify that the “DR” field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the “DR” field has been set to DR=4, 5, 6, or 7 in Part 3.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS”** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "0" (from "1") to indicate that Register 17_{16} has changed.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 3.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 3.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 3.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.4 Part 4 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 2 (§2.2.25.6 and §2.2.25.6.1)

Notes:

1. *The primary intent of Part 4 beyond data validation in Register 50_{16} is to validate Declaration of Capability while starting Register 50_{16} Servicing with a single parameter, e.g., Roll Angle.*
2. *Review all subparagraphs of Part 4 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 2:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, provide the transponder with the following Roll Angle data at a minimum rate of 5 per second in order to provide appropriate Roll Angle information.

Roll Angle (degrees)			
[See Note 1]		[See Note 2]	
Data Value (degrees)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees)**	**Rounded Input Encoding**
- 29.9981689 (330.0018311)	1_110 1010 1010 1011	-30.0585937 (329.9414063)	1_1 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = Right Wing Down, 1 = -180 or Left Wing Down*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded a resolution of 0.17578125 degrees; therefore,

   1_110 1010 101 0 1011
   + 000 0000 000 1 0000
   1_110 1010 101 1 1010 = 1_1 0101 0101

   Register 50_{16} "MB" encoding = 1_1 0101 0101 (bits 2 through 11) (355 Hex)

Note: Register 50_{16} does not take the 90 degree bit: Therefore, to get the real value of the 355 Hex encoding, the sign must be extended to result in the actual two's complement encoding of 755 Hex which is equivalent to 329.9414063 or -30.0585937 degrees.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Track Angle data.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Ground Speed data.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Track Angle Rate data.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Airspeed data.

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as Roll Angle data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Track and Turn Report Data as follows:

Part 4.b.(3) DF = 20, Track and Turn Report "MB" Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	1	1	1 0101 0101	0	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	00 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 48 (bit 16 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been re-started because of Roll Angle data being provided.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3.2.8 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 4.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 4.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed as servicing on Register 50_{16} has changed because of having Roll Angle data.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 4. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 4.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 4.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.5 Part 5 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 3 (§2.2.25.6 and §2.2.25.6.1)

Repeat Part 3:

2.7.6.6 Part 6 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 4 (§2.2.25.6 and §2.2.25.6.1)

<u>Notes:</u>

1. *The primary intent of Part 6 beyond data validation in Register 50_{16} is to validate Declaration of Capability while starting Register 50_{16} Servicing with a single parameter, e.g., True Track Angle.*
2. *Review all subparagraphs of Part 6 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data / Source Change - Set 4:</u>** (§2.2.25.6.2)

(1). <u>Roll Angle Data Input:</u> (§2.2.25.6.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Roll Angle data.

(2). <u>True Track Angle Data Input:</u> (§2.2.25.6.2.2)

Via an appropriate input interface, provide the transponder with the following Track Angle (True) data at a minimum rate of 5 per second in order to provide appropriate True Track Angle information.

Track Angle (True) (degrees)			
[See Note 1]		[See Note 2]	
Data Value (degrees)	Typical Binary Encoding	Rounded Input Data Value (degrees)	Rounded Input Encoding
+ 59.9963379	0__010 1010 1010 1010	59.94140625	0_01 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = East, 1 = West.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded to a resolution of 0.17578125 degrees; therefore,

   0_010 1010 101 0 1010

   + 000 0000 000 1 0000

   0_ 010 1010 101 1 1010

   Register 50_{16} "MB" encoding = 0_01 0101 0101 (bits 13 through 23) (155 Hex)

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Ground Speed data.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Track Angle Rate data.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Airspeed data.

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	"PC" =	"RR" =	"DI" =	"IIS" =	"RRS =	"X" =	"LOS" =	"XX" =	"TMS" =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as True Track Angle data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR"	=	4 or 5	if TCAS Information IS NOT available
	=	6 or 7	if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Track and Turn Report Data as follows:

Part 6.b.(3) DF = 20, Track and Turn Report "MB" Field													
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	1	0	01 0101 0101	0	00 0000 0000	0	0	0 0000 0000	0	00 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 48 (bit 16 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been re-started because of True Track Angle data.

d. **<u>Mode S Specific Services GICB Capability, Register 19_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

e. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **<u>Comm-B Broadcast Validation:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 6.a, verify that the “DR” field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the “DR” field has been set to DR=4, 5, 6, or 7 in Part 6.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). “DR” = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the “MB” field) set to 10 HEX (0001 0000).

(3). Bit 57 [“Mode S Specific Services Capability” (bit 25 of the “MB” field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 [“SIC” subfield (bit 35 of the “MB” field)] set to ONE (1) to indicate that the transponder does have “SI” capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the “MB” field)] toggled to “1” (from “0”) to indicate that Register 17_{16} has changed as servicing on Register 50_{16} has changed because of having True Track Angle data

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 6. g. (e.g., the last step) until the transponder replies with a DF=20 reply with “DR” NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 6.b.(2) is 18 ±1 second.

Note: *At this time, the “B” timer started in Part 6.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.7 Part 7 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 5 (§2.2.25.6 and 2.2.25.6.1)

Repeat Part 3:

2.7.6.8 Part 8 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 6 (§2.2.25.6 and 2.2.25.6.1)

Notes:

1. *The primary intent of Part 8 beyond data validation in Register 50_{16} is to validate Declaration of Capability while starting Register 50_{16} servicing with a single parameter, e.g., Ground Speed data.*
2. *Review all subparagraphs of Part 8 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 6:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Roll Angle data.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Track Angle data.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, provide the transponder with the following Ground Speed data at a minimum rate of 5 per second in order to provide appropriate Ground Speed information.

Ground Speed (knots)			
[See Note 1]		**[See Note 2]**	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
+ 1365.25	0__010 1010 1010 1010	**1364.00**	10 1010 1010

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded a resolution of 2.0 knots; therefore,

   10 1010 1010 1010
   + 00 0000 0000 1000

   10 1010 1011 0010

   Register 50_{16} "MB" encoding = 10 1010 1011 (bits 25 through 34) (2AA Hex)

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Track Angle Rate data.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Airspeed data.

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within **1.3** seconds of providing the transponder with data as detailed in Part 8.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as Ground Speed data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Track and Turn Report Data as follows:

Part 8.b.(3) DF = 20, Track and Turn Report "MB" Field													
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	0	0	00 0000 0000	1	10 1010 1011	0	0	0 0000 0000	0	00 0000 0000

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 8.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 48 (bit 16 of the “MB” field) set to “1” to indicate that Register 50_{16} servicing capability has been re-started because of Ground Speed data.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 8.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3.2.8 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 8.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 8.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 8.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed as servicing on Register 50_{16} has changed because of having Ground Speed data.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 8.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 8.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 8.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.9 Part 9 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 7 (§2.2.25.6 and §2.2.25.6.1)

Repeat Part 3:

2.7.6.10 Part 10 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 8 (§2.2.25.6 and §2.2.25.6.1)

Notes:

1. *The primary intent of Part 10 beyond data validation in Register 50_{16} is to validate Declaration of Capability while starting Register 50_{16} servicing with a single parameter, e.g., Track Angle Rate data.*
2. *Review all subparagraphs of Part 10 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 8:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Roll Angle data.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Track Angle data.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Ground Speed data.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, provide the transponder with the following Track Angle Rate data at a minimum rate of 5 per second in order to provide appropriate Track Angle Rate information.

Track Angle Rate (degrees/second)			
[See Note 1]		**[See Note 2]**	
Data Value (degrees/second)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees/second)**	**Rounded Input Encoding**
+ 10.65625	0__010 1010 1010	+10.65625	0_1 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = Clockwise (CW) = Right, 1 = Counter-Clockwise (CCW) = Left.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*

   Data must be rounded a resolution of 0.03125 degrees; therefore,
   0_010 1010 101 0
   + 000 0000 000 1
   0_010 1010 101 1

   Register 50_{16} "MB" encoding = 0_1 0101 0101 (bit 36 through 45) (155 Hex)

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Airspeed data.

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as Ground Speed data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the “DR” field changes, start a Test Timer to monitor that the “B”-Timer runs for 18 ±1.0 seconds.

“DR” = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply “MB” field provides Track and Turn Report Data as follows:

Part 10.b.(3) DF = 20, Track and Turn Report "MB" Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
“MB” Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	0	0	00 0000 0000	0	00 0000 0000	1	0	1 0101 0101	0	00 0000 0000

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 48 (bit 16 of the “MB” field) set to “1” to indicate that Register 50_{16} servicing capability has been re-started because of Track Angle Rate data.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3.2.8 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 10.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 10.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed as servicing on Register 50_{16} has changed because of having Track Angle Rate data.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 10.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 10.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 10.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.11 Part 11 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 9 (§2.2.25.6 and §2.2.25.6.1)

Repeat Part 3:

2.7.6.12 Part 12 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 10 (§2.2.25.6 and §2.2.25.6.1)

Notes:

1. *The primary intent of Part 12 beyond data validation in Register 50_{16} is to validate Declaration of Capability while starting Register 50_{16} servicing with a single parameter, e.g., True Airspeed data.*
2. *Review all subparagraphs of Part 12 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 10:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Roll Angle data.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with True Track Angle data.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Ground Speed data.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Track Angle Rate data.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, provide the transponder with the following True Airspeed data at a minimum rate of 5 per second in order to provide appropriate True Airspeed information.

True Air Speed (knots) - ADS			
[See Note 1]		[See Note 2]	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
682.625	0__010 1010 1010 1010	**682.00**	01 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 50_{16}.*
   Data must be rounded to a resolution of 2.0 knots; therefore:
   0_010 1010 101 0 1010
   + 000 0000 000 1 0000
   0_010 1010 101 1 1010 01 0101 0101

Register 50_{16} "MB" encoding = 01 0101 0101 (bits 47 through 56) (155 Hex)

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 12.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as True Airspeed data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the DF=20 reply "MB" field provides Track and Turn Report Data as follows:

Part 12.b.(3) DF = 20, Track and Turn Report "MB" Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	0	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	1	01 0101 0101

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 12.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 48 (bit 16 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been re-started because of True Airspeed data.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 12.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **<u>Mode S Specific Services GICB Capability, Register 19_{16}:</u>** (§2.2.25.3.2.8 and §2.2.25.3.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 12.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 12.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 12.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed as servicing on Register 50_{16} has changed because of having True Airspeed data.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 12.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 12.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 12.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.13 Part 13 – Register 50_{16} - Track and Turn Report - Data Change Validation - Set 11 (§2.2.25.6 and §2.2.25.6.1)

a. **Data / Source Change - Sets 11:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

For each line Item # in the following table (Table 13.a(1)), provide the transponder with Roll Angle data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(1): Register 50_{16} (Register 50_{16}) Roll Angle (degrees)								
Item #	**Type of Value**	**Generic Roll Angle Input (degrees) [Binary (BNR)]**			**Register 50_{16} (Register 50_{16}) Roll Angle (degrees)**			
		Status	**Sense (See Note 2)**	**Data Value (degrees)**	**Status (bit 1)**	**Sense (See Note 2)**	**Decimal Value (degrees)**	**Binary Value (bit 2 ----- 11) (See Note 3)**
1	Basic	Valid	Left (CCW)	- 29.88 (330.12)	1	Left	- 29.8828125 (330.1171875)	1_1 0101 0110
2	Basic	Valid	Right (CW)	59.94	1	Right	59.94140611	0_1 0101 0101
3	Basic	Valid	Left (CCW)	- 65.92 (294.08)	1	Left	65.91796875	1_0 1000 1001
4	Basic	Valid	Left (CCW)	-77.87 (282.13)	1	Left	- 77.8710944 (282.1289056)	1_0 0100 0101
5	Basic	Valid	Right (CW)	83.85	1	Right	83.84765606	0_1 1101 1101
6	Basic	Valid	Left (CCW)	- 41.84 (318.1600)	1	Left	- 41.8359375 (318.1640625)	1_1 0001 0010
7	Max	Valid	Left (CCW)	- 100.00 (260.00)	1	Left	-90 (270)	1_0 0000 0000
8	Min	Valid	Right (CW)	0	1	Left	0	0_0 0000 0000
9	Rounded (½ LSB)	Valid	Right (CW)	60.21	1	Right	60.29296875	0_1 0101 0111
10	Rounded (¼ LSB)	Valid	Right (CW)	59.98	1	Right	59.94140625	0_1 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_0 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being Clockwise (CW), commonly meaning Right Wing Down, or (b) Negative, being Counter-Clockwise (CCW), commonly meaning Left Wing Down.*
2. *Register 50_{16} Sense refers to (a) "1" for negative or Left Wing Down, or (b) "0" for positive or Right Wing Down.*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 2 being to the left of the "Underscore".*

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

For each line Item # in the following table (Table 13.a(2)), provide the transponder with True Track Angle data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(2): Register 50_{16} (Register 50_{16}) True Track Angle (degrees)								
Item #	Type of Value	Generic True Track Angle Input (degrees) [Binary (BNR)]			Register 50_{16} (Register 50_{16}) True Track Angle (degrees)			
		Status	Sense (See Note 2)	Data Value (degrees)	Status (bit 12)	Sense (See Note 2)	Decimal Value (degrees)	Binary Value (bit 13 ----- 23) (See Note 3)
1	Basic	Valid	Left (CCW)	- 120.10 (239.9)	1	Left	- 120.0585937 (239.9414063)	1_01 0101 0101
2	Basic	Valid	Right (CW)	119.90	1	Right	119.8828125	0_10 1010 1010
3	Basic	Valid	Left (CCW)	- 24.10 (335.9)	1	Left	- 24.0820312 (335.9179688)	1_11 0111 0111
4	Basic	Valid	Right (CW)	167.85	1	Right	167.8710938	0_11 1011 1011
5	Basic	Valid	Left (CCW)	- 96.15 (263.85)	1	Left	- 96.1523437 263.8476563	1_01 1101 1101
6	Basic	Valid	Left (CCW)	- 48.15 (311.85)	1	Left	- 48.1640625 (311.8359375)	1_10 1110 1110
7	Basic	Valid	Left (CCW)	- 0.20 (359.80)	1	Left	- 0.1757812 (359.8242188)	1_11 1111 1111
8	Basic	Valid	Right (CW)	0	1	Right	0	0_00 0000 0000
9	Rounded (½ LSB)	Valid	Right (CW)	60.25	1	Right	60.29296875	0_01 0101 0111
10	Rounded (¼ LSB)	Valid	Right (CW)	60.00	1	Right	59.94140625	0_01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_00 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being Clockwise (CW), commonly meaning East of North, or (b) Negative, being Counter-Clockwise (CCW), commonly meaning West of North.*
2. *Register 50_{16} Sense refers to (a) "1" for negative or West, or (b) "0" for positive or East.*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 13 being to the left of the "Underscore".*

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

For each line Item # in the following table (Table 13.a(3)), provide the transponder with Ground Speed data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(3): Register 50_{16} (Register 50_{16}) Ground Speed (knots)						
Item #	Type of Value	Generic Ground Speed (knots) [Binary (BNR)]		Register 50_{16} (Register 50_{16}) Ground Speed (knots)		
		Status	Data Value (knots)	Status (bit 24)	Decimal Value (knots)	Binary Value (bit 25 ----- 34)
1	Basic	Valid	1364	1	1364	10 1010 1010
2	Basic	Valid	682	1	682	01 0101 0101
3	Basic	Valid	1774	1	1774	11 0111 0111
4	Basic	Valid	1910	1	1910	11 1011 1011
5	Basic	Valid	954	1	954	01 1101 1101
6	Basic	Valid	1500	1	1500	10 1110 1110
7	Max	Valid	3006	1	2046	11 1111 1111
8	Min	Valid	0	1	0	00 0000 0000
9	Rounded (½ LSB)	Valid	683	1	684	01 0101 0110
10	Rounded (¼ LSB)	Valid	682.5	1	682	01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	00 0000 0000

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

For each line Item # in the following table (Table 13.a(4)), provide the transponder with Track Angle Rate data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(4): Register 50_{16} (Register 50_{16}) Track Angle Rate (degrees/second)

Item #	Type of Value	Generic Track Angle Rate Input (degrees/second) [Binary (BNR)]			Register 50_{16} (Register 50_{16}) Track Angle Rate (degrees/second)			
		Status	Sense (See Note 2)	Data Value (degrees)	Status (bit 35)	Sense (See Note 2)	Decimal Value (degrees)	Binary Value (bits 36 ---- 45) (See Note 3)
1	Basic	Valid	Left (CCW)	- 10.68	1	Left	- 10.6875	1_0 1010 1010
2	Basic	Valid	Right (CW)	10.65	1	Right	10.65625	0_1 0101 0101
3	Basic	Valid	Left (CCW)	- 4.275	1	Left	- 4.28125	1_1 0111 0111
4	Basic	Valid	Left (CCW)	- 2.16	1	Left	- 2.15625	1_1 1011 1011
5	Basic	Valid	Left (CCW)	14.91	1	Left	14.90625	0_1 1101 1101
6	Basic	Valid	Left (CCW)	- 8.565	1	Left	- 8.5625	1_0 1110 1110
7	Basic	Valid	Left (CCW)	-0.030	1	Left	- 0.03125	1_1 1111 1111
8	Basic	Valid	Right (CW)	0	1	Right	0	0_0 0000 0000
9	Rounded (½ LSB)	Valid	Right (CW)	10.68	1	Right	10.6875	0_1 0101 0110
10	Rounded (¼ LSB)	Valid	Right (CW)	10.665	1	Right	10.6875	0_1 0101 0110
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_0 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being Clockwise (CW), commonly meaning East of North, or (b) Negative, being Counter-Clockwise (CCW), commonly meaning West of North.*
2. *Register 50_{16} Sense refers to (a) "1" for negative or West, or (b) "0" for positive or East.*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 36 being to the left of the "Underscore".*

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

For each line Item # in the following table (Table 13.a(5)), provide the transponder with True Airspeed data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(5): Register 50_{16} (Register 50_{16}) True Airspeed (knots)

Item #	Type of Value	Generic True Airspeed (knots) [Binary (BNR)]		Register 50_{16} (Register 50_{16}) True Airspeed (knots)		
		Status	Data Value (knots)	Status (bit 46)	Decimal Value (knots)	Binary Value (bits 47 ---56)
1	Basic	Valid	1364	1	1364	10 1010 1010
2	Basic	Valid	682	1	682	01 0101 0101
3	Basic	Valid	1774	1	1774	11 0111 0111
4	Basic	Valid	1910	1	1910	11 1011 1011
5	Basic	Valid	954	1	954	01 1101 1101
6	Basic	Valid	1500	1	1500	10 1110 1110
7	Max	Valid	3006	1	2046	11 1111 1111
8	Min	Valid	0	1	0	00 0000 0000
9	Rounded (½ LSB)	Valid	683.125	1	684	01 0101 0110
10	Rounded (¼ LSB)	Valid	682.625	1	682	01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	00 0000 0000

b. **Register 50_{16} Capability Verification:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 13.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply.

(1). For each line Item # in Table 13.a(1) with "MB" field Status (bit 1) equivalent to that shown in the Status (bit 1) column of Table 13.a(1).

(2). For each line Item # in Table 13.a(1), with "MB" field bits 2 - 11 equivalent to that shown in the Binary Value (bits 2 - 11) column of Table 13.a(1).

(3). For each line Item # in Table 13.a(2) with "MB" field Status (bit 12) equivalent to that shown in the Status (bit 14) column of Table 14.a(2).

(4). For each line Item # in Table 13.a(2), with "MB" field bits 13 - 23 equivalent to that shown in the Binary Value (bits 13 - 23) column of Table 13.a(2).

(5). For each line Item # in Table 13.a(3) with "MB" field Status (bit 24) equivalent to that shown in the Status (bit 24) column of Table 13.a(3).

(6). For each line Item # in Table 13.a(3), with "MB" field bits 25 - 34 equivalent to that shown in the Binary Value (bits 25 - 34) column of Table 13.a(3).

(7). For each line Item # in Table 13.a(4) with "MB" field Status (bit 35) equivalent to that shown in the Status (bit 35) column of Table 13.a(4).

(8). For each line Item # in Table 13.a(4), with "MB" field bits 36 - 45 equivalent to that shown in the Binary Value (bits 36 - 45) column of Table 13.a(4).

(9). For each line Item # in Table 13.a(5) with "MB" field Status (bit 46) equivalent to that shown in the Status (bit 46) column of Table 13.a(5).

(10). For each line Item # in Table 13.a(5), with "MB" field bits 47 - 56 equivalent to that shown in the Binary Value (bits 47 - 56) column of Table 13.a(5).

Note: *Cumulative results are as shown in the following table.*

Part 13.b. DF = 20, Track and Turn Report "MB" Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
Data: / Item #	**Status**	**Sign**	**Data**	**Status**	**Sign**	**Data**	**Status**	**Data**	**Status**	**Sign**	**Data**	**Status**	**Data**
1	1	1	1 0101 0110	1	1	01 0101 0101	1	10 1010 1010	1	1	0 1010 1010	1	10 1010 1010
2	1	0	1 0101 0101	1	0	10 1010 1010	1	01 0101 0101	1	0	1 0101 0101	1	01 0101 0101
3	1	1	0 1000 1001	1	1	11 0111 0111	1	11 0111 0111	1	1	1 0111 0111	1	11 0111 0111
4	1	1	0 0100 0101	1	0	11 1011 1011	1	11 1011 1011	1	1	1 1011 1011	1	11 1011 1011
5	1	0	1 1101 1101	1	1	01 1101 1101	1	01 1101 1101	1	0	1 1101 1101	1	01 1101 1101
6	1	1	1 0001 0010	1	1	10 1110 1110	1	10 1110 1110	1	1	0 1110 1110	1	10 1110 1110
7	1	1	0 0000 0000	1	1	11 1111 1111	1	11 1111 1111	1	1	1 1111 1111	1	11 1111 1111
8	1	0	0 0000 0000	1	0	00 0000 0000	1	00 0000 0000	1	0	0 0000 0000	1	00 0000 0000
9	1	0	1 0101 0111	1	0	01 0101 0111	1	01 0101 0110	1	0	1 0101 0110	1	01 0101 0110
10	1	0	1 0101 0101	1	0	01 0101 0101	1	01 0101 0101	1	0	1 0101 0110	1	01 0101 0101
11	0	0	0 0000 0000	0	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	00 0000 0000

2.7.6.14 Part 14 – Reduced Data Rate (§2.2.25.6.3)

Notes:

1. *The primary intent of Part 14 beyond data validation in Register 50_{16} is to validate Declaration of Capability as data inputs are reduced to rates that are less than the minimum acceptable rate.*
2. *Review all subparagraphs of Part 14 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change:** (§2.2.25.6.2)

(1). Roll Angle Data Input: (§2.2.25.6.2.1)

Via an appropriate input interface, set the rate at which valid Roll Angle data is provided to less than once in 2.6 seconds.

(2). True Track Angle Data Input: (§2.2.25.6.2.2)

Via an appropriate input interface, set the rate at which valid True Track Angle data is provided to less than once in 2.6 seconds.

(3). Ground Speed Data Input: (§2.2.25.6.2.3)

Via an appropriate input interface, set the rate at which valid Ground Speed data is provided to less than once in 2.6 seconds.

(4). Track Angle Rate Data Input: (§2.2.25.6.2.4)

Via an appropriate input interface, set the rate at which valid Track Angle Rate data is provided to less than once in 2.6 seconds.

(5) True Airspeed Data Input: (§2.2.25.6.2.5)

Via an appropriate input interface, set the rate at which valid True Airspeed data is provided to less than once in 2.6 seconds.

b. **Register 50_{16} Validation:** (§2.2.25.6 through §2.2.25.6.3)

Within 1.3 seconds of changing the data sources in Part 14.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} Track and Turn Report Data:

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents (e.g., servicing) of Register 50_{16} changing as data for Register 50_{16} has effectively been terminated. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides data with:

Part 3.b.(3) DF = 20, Track and Turn Report "MB" Field														
Reply Bits:	33	34	35 ---------- 43	44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79 ---------- 88
"MB" Bits:	1	2	3 ----------- 11	12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47 --------- 56
Field:	**Roll Angle**			**True Track Angle**			**Ground Speed**		**Track Angle Rate**			**True Airspeed**	
	Status	Sign	Data	Status	Sign	Data	Status	Data	Status	Sign	Data	Status	Data
Data:	0	0	0 0000 0000	0	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	00 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.4 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 14.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 48 (bit 16 of the "MB" field) set to "0" to indicate that Register 50_{16} servicing capability has been changed as data for Register 50_{16} has been terminated.

d. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 14.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 50_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3 and §2.2.25.3.3)

Within FIVE (5) seconds of the interrogation/reply sequence in Part 14.b, Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

f. **<u>Comm-B Broadcast Validation:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 50_{16} - Track and Turn Report data monitor the "DR" field in the reply.

REGISTER 50_{16} TRACK AND TURN REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**21** (15 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 14.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **<u>Comm-B Broadcast Extraction:</u>** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 14.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 through 40 (bits 1 through 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability during the power-on cycle.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "0" (from "1") to indicate that Register 17_{16} has changed.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 14.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 14.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 14.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.6.15 Part 15 – Multiple Data Sources (§2.2.25 through §2.2.25.4, and §2.2.25.6)

If Multiple Data Sources of Register 50_{16} parameters are provided to the Unit-Under-Test (UUT), then REPEAT all applicable sections of Part 2 for each additional data source that was not tested while performing Parts 1 through 13 above.

<u>Note:</u> *GPS Data Sources may not provide data more often than once every 1.2 seconds. If GPS Data Sources are used to provide data, ensure that the data is provided at the minimum rate of once every 1.2 seconds. For Register 50_{16}, this may apply to the True Track Angle data and/or Ground Speed data.*

2.7.7 Register 60_{16} – Enhanced Surveillance – Protocol and Interface (§2.2.25.8)

<u>Introduction:</u>

The intent of this test procedure is to validate all aspects of Enhanced Surveillance Servicing of Register 60_{16}.

2.7.7.1 Part 1 – Capability Verification (§2.2.25.8)

<u>Test Procedure:</u>

<u>Note:</u> *The primary intent of Part 1 is to validate appropriate capability declaration of No Capability prior to providing data to Register 60_{16}.*

Ensure that NO Flight Identification or Aircraft Registration data is being provided to the transponder.

Ensure that the TCAS / Transponder interface is NOT ACTIVE. If the interface is active, TCAS will provide data to set the Data Link Capability and thereby compromise the results of the following tests. Likewise, TCAS could attempt to set the Resolution Advisory Report and thereby compromise the results of the following tests.

Ensure that no other data is being provided to the transponder that could result in the loading of BDS registers internal to the transponder. This includes NO Servicing of Register 40_{16} and / or Register 50_{16}.

Disable the Extended Squitter function prior to starting the following procedures in order to keep from setting various BDS registers during the following tests.

a. **Register 60_{16} Initial Setting – Part A:** (§2.2.25.8)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} Heading and Speed Report.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ---- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	22 (16 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 ("BDS" subfield (bits 1 through 56 of the "MB" field)] set to ALL ZERO (0).

b. **Register 60_{16} Initial Setting – Part B:** (§2.2.25.8)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} Heading and Speed Report.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with the same content as required in section §2.7.7.1.a.

Note: *Two separate interrogations are used as Register 60_{16} can be extracted by using either the Data Source or Extended Data Source extraction protocols.*

c. **Data Link Capability Report, Register 10_{16}:** (§2.2.25.1)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 10_{16} Data Link Capability Report.

REGISTER 10_{16} DATA LINK CAPABILITY GICB EXTRACTION DATA SOURCE INTERROGATION SETUP					
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 ---- 32
				"SD"	
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"NOT ASSIGNED" =**
4	0	**17** (11 HEX)	**0**	0	0

Verify that the transponder replies with a DF=20 reply having:

(1). Bit 65 ["AIS" subfield (bit 33 of the "MB" field)] set to "0" to indicate NO Flight Identification capability.

(2). Bit 57 [Mode S Specific Services Capability (bit 25 of the "MB" field)] set to "0" to indicate Mode S Specific Services Capability has not been established.

(3). Bit 67 [Surveillance Identifier ("SI") (bit 35 of the "MB" field)] set to "1" to indicate that the transponder DOES Have "SI" Capability.

(4). Bit 68 [Common Usage GICB Capability Report (bit 36 of the "MB" field)] set to "0" to indicate that there has been no change in the Common Usage GICB Capability Report, Register 17_{16}.

d. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bits 33 - 60 (bits 1 - 28 of the "MB" field) set to "0" to indicate NO Capability or capability changes in the Common Usage GICB Capability Report, Register 17_{16}.

(2). Bits 61 - 88 (bits 29 - 56 of the "MB" field) set to "0" since these bits are Reserved or "Don't Care".

e. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 - 88 (bits 1 - 56 of the "MB" Field) set to ZERO (0) to indicate NO Capability has been established to service the BDS Codes designated in Register 18_{16}.

f. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register 19_{16}.

g. **Mode S Specific Services GICB Capability, Register $1A_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1A_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1A_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**A**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1A_{16}$.

h. **Mode S Specific Services GICB Capability, Register $1B_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1B_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1B_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**B**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1B_{16}$.

i. **Mode S Specific Services GICB Capability, Register $1C_{16}$:** (§2.2.25.3)

Interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register $1C_{16}$ Mode S Specific Services GICB Capability:

REGISTER $1C_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**C**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to "0" to indicate NO Capability has been established to service the BDS Codes designated in Register $1C_{16}$.

2.7.7.2 Part 2 – Register 60_{16} - Heading and Speed Report Validation (§2.2.25.8 and §2.2.25.8.1)

Notes:

1. *The primary intent of Part 2 beyond data validation in Register 60_{16} is to validate capability declaration.*
2. *Review all subparagraphs of Part 2 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data Input Initialization:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)

Via an appropriate input interface, provide the transponder with the following Magnetic Heading data at a minimum rate of 5 per second in order to provide appropriate Magnetic Heading information.

Magnetic Heading (degrees)			
[See Note 1]		[See Note 2, 3]	
Data Value (degrees)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees)**	**Rounded Input Encoding**
+ 119.9981689	0__101 0101 0101 0101	+ 120.0585938	0_10 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = East, 1 = West.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*

   Data must be rounded to a resolution of 0.17578125 degrees; therefore,

   0_101 0101 010 1 0101

   + 000 0000 000 1 0000

   0_101 0101 011 0 0101

   Register 60_{16} "MB" encoding = 0_10 1010 1011 (bits 2 through 12) (2AB Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 2 being to the left of the "Underscore".*

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

Via an appropriate input interface, provide the transponder with the following Indicated Airspeed data at a minimum rate of 5 per second in order to provide appropriate Indicated Airspeed information.

Indicated Airspeed Speed (knots) - ADS			
[See Note 1]		[See Note 2]	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
341.3125	0__01 0101 0101 0101	341.00	01 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*

   Data must be rounded to a resolution of 1.0 knots; therefore,

   01 0101 0101 0 101

   + 00 0000 0000 1 000

   01 0101 0101 1 101

   Register 60_{16} "MB" encoding = 01 0101 0101 (bits 14 through 23) (155 Hex)

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

Via an appropriate input interface, provide the transponder with the following Mach data at a minimum rate of 5 per second in order to provide appropriate Mach information.

Mach (milli-Mach) - ADS			
[See Note 1]		[See Note 2]	
Data Value (mill-Mach)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
+1365.3125 (1.3653125 Mach)	0__0101 0101 0101 0101	341.00	01 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 4 milli-mach; therefore,
   0101 0101 0 1 01 0101
   + 0000 0000 0 0 10 0000
   0101 0101 0 1 11 0101
   Register 60_{16} "MB" encoding = 01 0101 0101 (bits 25 through 34) (155 Hex)

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, provide the transponder with the following Barometric Altitude Rate data at a minimum rate of 5 per second in order to provide appropriate Barometric Altitude Rate information.

Barometric Altitude Rate (feet/minute) - ADS			
[See Note 1]		[See Note 2, 3]	
Barometric Altitude Rate (feet/minute)	**Typical Binary Encoding**	**Rounded Input Data Value (feet/minute)**	**Rounded Input Encoding**
+13648.00	0__011 0101 0101	13648.00	0_1 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is "0" for "UP" and "1" for "Down".*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 32 feet/minute; therefore,
   0_011 0101 01 0 1
   + 0_000 0000 00 0 1
   0_011 0101 01 10
   Register 60_{16} "MB" encoding = 0_1 1010 1011 (bits 36 through 45) (1AB Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 36 being to the left of the "Underscore".*

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, provide the transponder with the following Inertial Vertica Rate data at a minimum rate of 5 per second in order to provide appropriate Inertial Vertical Rate information.

Inertial Vertical Rate (feet/minute) - FMS / IRS			
[See Note 1]		[See Note 2, 3]	
Inertial Vertical Rate (feet/minute)	**Typical Binary Encoding**	**Rounded Input Data Value (feet/minute)**	**Rounded Input Encoding**
+9637.00	0__010 0101 1010 0101	9632.00	0_1 0010 1101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is "0" for "UP" and "1" for "Down".*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 32 feet/minute; therefore,
   0_010 0101 10 1 0 0101
   + 0_000 0000 00 0 1 0000
   0_010 0101 10 1 1 0101
   Register 60_{16} "MB" encoding = 0_1 0010 1101 (bits 47 through 56) (12D Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 47 being to the left of the "Underscore".*

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	"PC" =	"RR" =	"DI" =	"IIS" =	"RRS =	"X" =	"LOS" =	"XX" =	"TMS" =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 2.b.(3) DF = 20, Heading and Speed "MB" Field														
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	1	0	10 1010 1011	1	01 0101 0101	1	01 0101 0101	1	0	1 1010 1011	1	0	1 0010 1101

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been established and that data is valid.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the “MB” field) set to “1” to indicate that Register 60_{16} servicing capability has been established.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the “DR” field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 2.a, verify that the “DR” field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 2.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 2. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 2.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 2.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.3 Part 3 – Register 60_{16} - Heading and Speed Report - Data Change Validation (§2.2.25.8 and §2.2.25.8.1)

Notes:

1. *The primary intent of Part 3 beyond data validation in Register 60_{16} is to validate Declaration of Capability as data has been terminated.*
2. *Review all subparagraphs of Part 3 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 1:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Magnetic Heading data.

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Mach data.

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Barometric Altitude Rate data.

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with Inertial Vertical Rate data.

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as provision of all parameter data has been terminated. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 2.b.(3) DF = 20, Heading and Speed "MB" Field													
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	0	0 0000 0000

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "0" to indicate that Register 60_{16} servicing capability has been changed as data for Register 60_{16} has been terminated.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the "DR" field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 2.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 3.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "0" (from "1") to indicate that Register 17_{16} has changed.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 3. g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 3.b.(2) is 18 ±1 second.

Note: *At this time, the "B" timer started in Part 3.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.4 Part 4 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 2 (§2.2.25.8 and §2.2.25.8.1)

Notes:

1. *The primary intent of Part 4 beyond data validation in Register 60_{16} is to validate Declaration of Capability while starting Register 6016 servicing with a single parameter, e.g., Roll Angle.*
2. *Review all subparagraphs of Part 4 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 2:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)

Via an appropriate input interface, provide the transponder with the following Magnetic Heading data at a minimum rate of 5 per second in order to provide appropriate Magnetic Heading information.

Magnetic Heading (degrees)			
[See Note 1]		**[See Note 2]**	
Data Value (degrees)	**Typical Binary Encoding**	**Rounded Input Data Value (degrees)**	**Rounded Input Encoding**
- 120.0036621 - (239.9963379)	1_010 1010 1010 1010	- 120.0585937 (239.9414062)	1_01 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit often referred to as 0 = East, 1 = West.*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*

   Data must be rounded to a resolution of 0.17578125 degrees; therefore,

   1 010 1010 101 0 1010
+ 0 000 0000 000 1 0000
1 010 1010 101 1 1010

   Register 60_{16} "MB" encoding = 1_01 0101 0101 (bits 2 through 12) (555 Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 2 being to the left of the "Underscore".*

(2). <u>Indicated Airspeed Data Input - ADS:</u> (§2.2.25.8.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(3). <u>Mach Data Input - ADS:</u> (§2.2.25.8.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Mach data.

(4). <u>Barometric Altitude Rate Data Input - ADS:</u> (§2.2.25.8.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Barometric Altitude Rate data.

(5). <u>Inertial Vertical Rate Data Input - FMS / IRS:</u> (§2.2.25.8.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with Inertial Vertical Rate data.

b. **<u>Register 60_{16} Capability Verification:</u>** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 4.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as Magnetic Heading data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR"	=	4 or 5	if TCAS Information IS NOT available
	=	6 or 7	if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 4.b.(3) DF = 20, Heading and Speed "MB" Field														
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	1	1	01 0101 0101	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	0	0 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 4.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS" =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been re-started because of Magnetic Heading data being provided.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 4.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP

1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 4.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP

1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the “MB” field) set to “1” to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the “DR” field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP

1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 4.a, verify that the “DR” field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the “DR” field has been set to DR=4, 5, 6, or 7 in Part 4.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). “DR” = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the “MB” field) set to 10 HEX (0001 0000).

(3). Bit 57 [“Mode S Specific Services Capability” (bit 25 of the “MB” field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 [“SIC” subfield (bit 35 of the “MB” field)] set to ONE (1) to indicate that the transponder does have “SI” capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the “MB” field)] toggled to “1” (from “0”) to indicate that Register 17_{16} has changed servicing on Register 60_{16} has changed because of having Magnetic Heading data.

h. **Comm-B Broadcast because of Data Link Capability Change Termination:** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 4.g, (e.g., the last step) until the transponder replies with a DF=20 reply with “DR” NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 4.b.(2) is 18 ±1 second.

Note: *At this time, the “B” timer started in Part 4.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.5 Part 5 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 3 (§2.2.25.8 and §2.2.25.8.1)

Repeat Part 3:

2.7.7.6 Part 6 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 4 (§2.2.25.8 and §2.2.25.8.1)

Notes:

1. *The primary intent of Part 6 beyond data validation in Register 60_{16} is to validate Declaration of Capability while starting Register 60_{16} Servicing with a single parameter, e.g., Indicated Airspeed.*
2. *Review all subparagraphs of Part 4 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 4:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Magnetic Heading data.

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

Via an appropriate input interface, provide the transponder with the following Indicated Airspeed data at a minimum rate of 5 per second in order to provide appropriate Indicated Airspeed information.

Indicated Airspeed Speed (knots) - ADS			
[See Note 1]		**[See Note 2]**	
Data Value (knots)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
682.625	0__10 1010 1010 1010	**683.00**	10 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 1.0 knots; therefore,

```
  10 1010 1010 1 010
+ 00 0000 0000 1 000
  10 1010 1011 0 010
```

Register 60_{16} "MB" encoding = 10 1010 1011 (bits 14 through 23) (2AB Hex)

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Mach data.

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Barometric Altitude Rate data.

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with Inertial Vertical Rate data.

b. **Register 60$_{16}$ Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 6.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60$_{16}$ - Heading and Speed Report data.

REGISTER 60$_{16}$ HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60$_{16}$ changing as Indicated Airspeed data has been re-started. This change causes a change to Register 17$_{16}$, which then forces a change to Register 10$_{16}$, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 6.b.(3) DF = 20, Heading and Speed "MB" Field														
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	1	10 1010 1011	0	00 0000 0000	0	0	0 0000 0000	0	0	0 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 6.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS"** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been re-started because of Indicated Airspeed data being provided.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 6.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **<u>Mode S Specific Services GICB Capability, Register 19_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 6.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **<u>Comm-B Broadcast Validation:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the "DR" field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 6.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **<u>Comm-B Broadcast Extraction:</u>** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 6.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed servicing on Register 60_{16} has changed because of having Indicated Airspeed data.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 6.g, (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 6.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 6.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.7 Part 7 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 5 (§2.2.25.8 and §2.2.25.8.1)

Repeat Part 3:

2.7.7.8 Part 8 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 6 (§2.2.25.8 and §2.2.25.8.1)

<u>Notes:</u>

1. *The primary intent of Part 8 beyond data validation in Register 60_{16} is to validate Declaration of Capability while starting Register 60_{16} servicing with a single parameter, e.g., Mach.*
2. *Review all subparagraphs of Part 8 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data / Source Change - Set 2:</u>** (§2.2.25.8.2)

(1). <u>Magnetic Heading Data Input:</u> (§2.2.25.8.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

Via an appropriate input interface, provide the transponder with the following Mach data at a minimum rate of 5 per second in order to provide appropriate Mach information.

Mach (milli-Mach) - ADS			
[See Note 1]		**[See Note 2]**	
Data Value (mill-Mach)	**Typical Binary Encoding**	**Rounded Input Data Value (knots)**	**Rounded Input Encoding**
+2730.625 (2.730625 Mach)	0__1010 1010 1010 1010	2732.00	10 1010 1011

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is always positive (e,g., = "0").*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 4 milli-mach; therefore,

1010 1010 1 0 10 1010
+ 0000 0000 0 0 10 0000
1010 1010 1 1 10 1010

Register 60_{16} "MB" encoding = 10 1010 1011 (bits 25 through 34) (2AB Hex)

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Barometric Altitude Rate data.

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with Inertial Vertical Rate data.

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 8.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as Mach data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 8.b.(3) DF = 20, Heading and Speed "MB" Field														
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	0	00 0000 0000	1	10 1010 1011	0	0	0 0000 0000	0	0	0 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17_{16}:</u>** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 8.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been re-started because of Mach data being provided.

d. **<u>Mode S Specific Services GICB Capability, Register 18_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 8.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **<u>Mode S Specific Services GICB Capability, Register 19_{16}:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 8.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the “MB” field) set to “1” to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the "DR" field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 8.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 8.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed servicing on Register 60_{16} has changed because of having Mach data.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 8.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 8.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 8.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.9 Part 9 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 7 (§2.2.25.8 and §2.2.25.8.1)

Repeat Part 3:

2.7.7.10 Part 10 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 8 (§2.2.25.8 and §2.2.25.8.1)

<u>Notes:</u>

1. *The primary intent of Part 10 beyond data validation in Register 60_{16} is to validate Declaration of Capability while starting Register 60_{16} servicing with a single parameter, e.g., Barometric Altitude Rate.*
2. *Review all subparagraphs of Part 10 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data / Source Change - Set 2:</u>** (§2.2.25.8.2)

(1). <u>Magnetic Heading Data Input:</u> (§2.2.25.8.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(2). <u>Indicated Airspeed Data Input - ADS:</u> (§2.2.25.8.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(3). <u>Mach Data Input - ADS:</u> (§2.2.25.8.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Mach data.

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, provide the transponder with the following Barometric Altitude Rate data at a minimum rate of 5 per second in order to provide appropriate Barometric Altitude Rate information.

Barometric Altitude Rate (feet/minute) - ADS			
[See Note 1]		**[See Note 2, 3]**	
Barometric Altitude Rate (feet/minute)	**Typical Binary Encoding**	**Rounded Input Data Value (feet/minute)**	**Rounded Input Encoding**
-13648.00	1_100 1010 1010	-13664.00	1_0 0101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is "0" for "UP" and "1" for "Down".*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 32 feet/minute; therefore,
   0_011 0101 01 0 1 (+13648)
   +0_000 0000 00 0 1 (round LSB)
   0_011 0101 01 1
   1_100 1010 10 0 (complement)
   +0_000 0000 00 1
   1_100 1010 10 1 (2's complement)
   Register 60_{16} "MB" encoding = 1__0 0101 0101 (bits 36 through 45) (1AB Hex)
3. *Data is shown encoded with the "Sign Bit", e.g., bit 36 being to the left of the "Underscore".*

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, terminate provision of valid data to the transponder with Inertial Vertical Rate data.

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as Barometric Altitude Rate data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the "DR" field changes, start a Test Timer to monitor that the "B"-Timer runs for 18 ±1.0 seconds.

"DR" = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the "DF"=20 reply "MB" field provides Data with:

Part 8.b.(3) DF = 20, Heading and Speed "MB" Field															
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
"MB" Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	0	00 0000 0000	0	00 0000 0000	1	1	0 0101 0101	0	0	0 0000 0000

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 10.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been re-started because of Barometric Altitude Rate data being provided.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 10.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the "MB" field) set to "1" to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 10.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the "DR" field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 10.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **<u>Comm-B Broadcast Extraction:</u>** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 10.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed servicing on Register 60_{16} has changed because of having Barometric Altitude Rate data.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 10.g. (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 10.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 10.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.11 Part 11 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 9 (§2.2.25.8 and §2.2.25.8.1)

Repeat Part 3:

2.7.7.12 Part 12 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 10 (§2.2.25.8 and §2.2.25.8.1)

<u>Notes:</u>

1. *The primary intent of Part 12 beyond data validation in Register 60_{16} is to validate Declaration of Capability while starting Register 60_{16} servicing with a single parameter, e.g., Inertial Vertical Rate.*
2. *Review all subparagraphs of Part 12 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **<u>Data / Source Change - Set 2:</u>** (§2.2.25.8.2)

(1). <u>Magnetic Heading Data Input:</u> (§2.2.25.8.2.1)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(2). <u>Indicated Airspeed Data Input - ADS:</u> (§2.2.25.8.2.2)

Via an appropriate input interface, terminate provision of valid data to the transponder with Indicated Airspeed data.

(3). <u>Mach Data Input - ADS:</u> (§2.2.25.8.2.3)

Via an appropriate input interface, terminate provision of valid data to the transponder with Mach data.

(4). <u>Barometric Altitude Rate Data Input - ADS:</u> (§2.2.25.8.2.4)

Via an appropriate input interface, terminate provision of valid data to the transponder with Barometric Altitude Rate data.

(5). <u>Inertial Vertical Rate Data Input - FMS / IRS:</u> (§2.2.25.8.2.5)

Via an appropriate input interface, provide the transponder with the following Inertial Vertical Rate data at a minimum rate of 5 per second in order to provide appropriate Inertial Vertical Rate information.

Inertial Vertical Rate (feet/minute) - FMS / IRS			
[See Note 1]		[See Note 2, 3]	
Inertial Vertical Rate (feet/minute)	**Typical Binary Encoding**	**Rounded Input Data Value (feet/minute)**	**Rounded Input Encoding**
- 9557	1_101 1010 1010 1011	9568	1_0 1101 0101

Notes:

1. *Data Input Value and Typical Binary Encoding represent the data as it is provided to the transponder in two's complement format. Sign Bit is "0" for "UP" and "1" for "Down".*
2. *Rounded Input Data Value and Rounded Input Encoding represent the data as it is expected to be seen in the "MB" field of Register 60_{16}.*
   Data must be rounded to a resolution of 32 feet/minute; therefore,
   0_010 0101 01 0 1 0101 (+9557)
   + 0_000 0000 00 0 1 0000 (round LSB)
   0_010 0101 01 1 0 0110
   1_101 1010 10 0 (complement)
   + 0_000 0000 00 1
   1_101 1010 10 1 (2's complement)

   Register 60_{16} "MB" encoding = 1_0 1101 0101 (bits 47 through 56
3. *Data is shown encoded with the "Sign Bit", e.g., bit 47 being to the left of the "Underscore".*

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 10.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the "B" timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*
2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as Inertial Vertical Rate data has been re-started. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the "DR" field. If the "DR" field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the “DR” field changes, start a Test Timer to monitor that the “B”-Timer runs for 18 ±1.0 seconds.

“DR” = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the “DF”=20 reply “MB” field provides Data with:

Part 8.b.(3) DF = 20, Heading and Speed ”MB” Field														
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
“MB” Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	1	1	0 1101 0101

c. **Common Usage GICB Capability Report, Register 17_{16}:** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 12.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17_{16} Common Usage GICB Capability Report:

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the “MB” field) set to “1” to indicate that Register 60_{16} servicing capability has been re-started because of Inertial Vertical Rate data being provided.

d. **Mode S Specific Services GICB Capability, Register 18_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 12.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18_{16} Mode S Specific Services GICB Capability:

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19_{16} servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the "MB" field) set to "1" to indicate that Register 18_{16} servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the "MB" field) set to "1" to indicate that Register 17_{16} servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 12.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the "MB" field) set to "1" to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the "DR" field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC"** =	**"RR"** =	**"DI"** =	**"IIS"** =	**"RRS** =	**"X"** =	**"LOS"** =	**"XX"** =	**"TMS"** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 12.a, verify that the "DR" field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the "DR" field has been set to DR=4, 5, 6, or 7 in Part 12.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "1" (from "0") to indicate that Register 17_{16} has changed servicing on Register 60_{16} has changed because of having Inertial Vertical Rate data.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 12.g, (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 12.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 12.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.13 Part 13 – Register 60_{16} - Heading and Speed Report - Data Change Validation - Set 11 (§2.2.25.8 and §2.2.25.8.1)

a. **<u>Data Input Initialization:</u>** (§2.2.25.8.2)

(1). <u>Magnetic Heading Data Input:</u> (§2.2.25.8.2.1)

For each line Item # in the following table (Table 13.a(1)), provide the transponder with Magnetic Heading data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(1): Register 60_{16} - Magnetic Heading (degrees)								
Item #	Type of Value	Generic Magnetic Heading Input (degrees) [Binary (BNR)]			Register 60_{16} Magnetic Heading (degrees)			
		Status	Sense (See Note 2)	Data Value (degrees)	Status (bit 1)	Sense (See Note 2)	Decimal Value (degrees)	Binary Value (bits 2 ---- 12) (See Note 3)
1	Basic	Valid	West (CCW)	- 120.05859375 (239.9414063)	1	Left	- 120.0585937 (239.9414063)	1_01 0101 0101
2	Basic	Valid	East (CW)	119.8828125	1	Right	119.8828125	0_10 1010 1010
3	Basic	Valid	West (CCW)	- 24.08203125 (335.9196875)	1	Left	- 24.08203125 (335.9179688)	1_11 0111 0111
4	Basic	Valid	East (CW)	167.87109375	1	Right	167.87109375	0_11 1011 1011
5	Basic	Valid	Left (CCW)	- 96.15234375 (263.8476563)	1	Left	- 96.15234375 263.8476563	1_01 1101 1101
6	Basic	Valid	Left (CCW)	- 48.1640625 (311.8359375)	1	Left	- 48.1640625 (311.8359375)	1_10 1110 1110
7	Basic	Valid	Left (CCW)	- 0.16479 (359.83521)	1	Left	- 0.17578125 (359.8242188)	1_11 1111 1111
8	Basic	Valid	Right (CW)	0	1	Right	0	0_00 0000 0000
9	Rounded (½ LSB)	Valid	Right (CW)	60.25	1	Right	60.29296875	0_01 0101 0111
10	Rounded (¼ LSB)	Valid	Right (CW)	60.00	1	Right	59.94140625	0_01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_00 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being Clockwise (CW), commonly meaning East of North, or (b) Negative, being Counter-Clockwise (CCW), commonly meaning West of North.*
2. *Register 60_{16} Sense refers to (a) "1" for negative or West of North, or (b) "0" for positive or East of North.*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 2 being to the left of the "Underscore".*

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

For each line Item # in the following table (Table 13.a(2)), provide the transponder with Indicated Airspeed data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(2): Register 60_{16} - Indicated Airspeed (knots)						
Item #	Type of Value	Generic Indicated Airspeed (knots) [Binary (BNR)]		Register 60_{16} Indicated Airspeed (knots)		
		Status	Data Value (knots)	Status (bit 13)	Decimal Value (knots)	Binary Value (bits 14 ---23)
1	Basic	Valid	682	1	682	10 1010 1010
2	Basic	Valid	341	1	341	01 0101 0101
3	Basic	Valid	887	1	887	11 0111 0111
4	Basic	Valid	955	1	955	11 1011 1011
5	Basic	Valid	477	1	477	01 1101 1101
6	Basic	Valid	750	1	750	10 1110 1110
7	Max	Valid	1024	1	1023	11 1111 1111
8	Min	Valid	0	1	0	00 0000 0000
9	Rounded (½ LSB)	Valid	342.75	1		01 0101 0111
10	Rounded (¼ LSB)	Valid	341.25	1		01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	00 0000 0000

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

For each line Item # in the following table (Table 13.a(3)), provide the transponder with Mach data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(3): Register 60_{16} - Mach (milli-Mach)

Item #	Type of Value	Generic Mach (milli-Mach) [Binary (BNR)]		Register 60_{16} Mach (milli-Mach)		
		Status	Data Value (knots)	Status (bit 24)	Decimal Value (knots)	Binary Value (bits 25 ---34)
1	Basic	Valid	1928	1	1928	01 1110 0010
2	Basic	Valid	1364	1	1364	01 0101 0101
3	Basic	Valid	3548	1	3548	11 0111 0111
4	Basic	Valid	3820	1	3820	11 1011 1011
5	Basic	Valid	1908	1	1908	01 1101 1101
6	Basic	Valid	3000	1	3000	10 1110 1110
7	Max	Valid	4096	1	4092	11 1111 1111
8	Min	Valid	0	1	0	00 0000 0000
9	Rounded (½ LSB)	Valid	1370	1	1372	01 0101 0111
10	Rounded (¼ LSB)	Valid	1365	1	1364	01 0101 0101
11	Invalid	Invalid	Not Applicable	0	0	00 0000 0000

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

For each line Item # in the following table (Table 13.a(4)), provide the transponder with Barometric Altitude Rate data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(4): Register 60_{16} - Barometric Altitude Rate (feet / minute)

Item #	Type of Value	Generic Barometric Altitude Rate (feet / minute) [Binary (BNR)]			Register 60_{16} Barometric Altitude Rate (feet / minute)			
		Status	Sense (See Note 2)	Data Value (feet / minute)	Status (bit 35)	Sense (See Note 2)	Decimal Value (feet / minute)	Binary Value (bits 36 ---- 45) (See Note 3)
1	Basic	Valid	0, +, UP	10912	1	UP	10912	0_1 0101 0101
2	Basic	Valid	1, -, Down	- 10912	1	Down	- 10912	1_0 1010 1011
3	Basic	Valid	1, -, Down	- 4384	1	Down	- 4384	1_1 0111 0111
4	Basic	Valid	1, -, Down	- 2208	1	Down	- 2208	1_1 1011 1011
5	Basic	Valid	0, +, UP	15264	1	UP	15264	0_1 1101 1101
6	Basic	Valid	1, -, Down	- 8768	1	Down	- 8768	1_0 1110 1110
7	Basic	Valid	1, -, Down	- 16384	1	Down	- 16356	1_0 0000 0000
8	Basic	Valid	0, +, UP	16356	1	UP	16352	0_1 1111 1111
9	Rounded (½ LSB)	Valid	0, +, UP	15248	1	UP	15264	0_1 1101 1101
10	Rounded (¼ LSB)	Valid	0, +, UP	15272	1	UP	15264	0_1 1101 1101
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_00 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being "UP", or (b) Negative, being "Down".*
2. *Register **60_{16}** Sense refers to (a) **"1"** for negative or "Down", or (b) **"0"** for positive or "UP".*
3. *Data is shown encoded with the "Sign Bit", e.g., bit **36** being to the left of the "Underscore".*

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

For each line Item # in the following table (Table 13.a(5)), provide the transponder with Inertial Vertical Rate data having a value as indicated in the "Data Value" (degrees) Column in the table.

Table 13.a(5): Register 60_{16} - Inertial Vertical Rate (feet / minute)

Item #	Type of Value	Generic Inertial Vertical Rate (feet / minute) [Binary (BNR)]			Register 60_{16} Inertial Vertical Rate (feet / minute)			
		Status	Sense (See Note 2)	Data Value (feet / minute)	Status (bit 46)	Sense (See Note 2)	Decimal Value (feet / minute)	Binary Value (bits 47 ---- 56) (See Note 3)
1	Basic	Valid	0, +, UP	10912	1	UP	10912	0_1 0101 0101
2	Basic	Valid	1, -, Down	- 10912	1	Down	- 10912	1_0 1010 1011
3	Basic	Valid	1, -, Down	- 4384	1	Down	- 4384	1_1 0111 0111
4	Basic	Valid	1, -, Down	- 2208	1	Down	- 2208	1_1 1011 1011
5	Basic	Valid	0, +, UP	15264	1	UP	15264	0_1 1101 1101
6	Basic	Valid	1, -, Down	- 8768	1	Down	- 8768	1_0 1110 1110
7	Basic	Valid	1, -, Down	- 16384	1	Down	- 16356	1_0 0000 0000
8	Basic	Valid	0, +, UP	16356	1	UP	16352	0_1 1111 1111
9	Rounded (½ LSB)	Valid	0, +, UP	15248	1	UP	15264	0_1 1101 1101
10	Rounded (¼ LSB)	Valid	0, +, UP	15272	1	UP	15264	0_1 1101 1101
11	Invalid	Invalid	Not Applicable	0	0	N/A	0	0_0 0000 0000

Notes:

1. *Input data Sense refers to (a) Positive, being "UP", or (b) Negative, being "Down".*
2. *Register 60_{16} Sense refers to (a) "1" for negative or "Down", or (b) "0" for positive or "UP".*
3. *Data is shown encoded with the "Sign Bit", e.g., bit 47 being to the left of the "Underscore".*

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 13.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP

1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				"SD"					
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"IIS" =**	**"RRS =**	**"X" =**	**"LOS" =**	**"XX" =**	**"TMS" =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply.

(1). For each line Item # in Table 13.a(1) with "MB" field Status (bit 1) equivalent to that shown in the Status (bit 1) column of Table 13.a(1).

(2). For each line Item # in Table 13.a(1), with "MB" field bit 2 through 12 equivalent to that shown in the Binary Value (bits 2 - 12) column of Table 13.a(1).

(3). For each line Item # in Table 13.a(2) with "MB" field Status (bit 13) equivalent to that shown in the Status (bit 13) column of Table 14.a(2).

(4). For each line Item # in Table 13.a(2), with “MB” field bits 14 through 23 equivalent to that shown in the Binary Value (bits 14 - 23) column of Table 13.a(2.

(5). For each line Item # in Table 13.a(3) with “MB” field Status (bit 24) equivalent to that shown in the Status (bit 24) column of Table 13.a(3).

(6). For each line Item # in Table 13.a(3), with “MB” field bits 25 through 34 equivalent to that shown in the Binary Value (bits 25 - 34) column of Table 13.a(3).

(7). For each line Item # in Table 13.a(4) with “MB” field Status (bit 35) equivalent to that shown in the Status (bit 35) column of Table 13.a(4).

(8). For each line Item # in Table 13.a(4), with “MB” field bits 36 through 45 equivalent to that shown in the Binary Value (bits 36 - 45) column of Table 13.a(4).

(9). For each line Item # in Table 13.a(5) with “MB” field Status (bit 46) equivalent to that shown in the Status (bit 46) column of Table 13.a(5).

(10). For each line Item # in Table 13.a(5), with “MB” field bits 47 through 56 equivalent to that shown in the Binary Value (bits 47 - 56) column of Table 13.a(5).

Note: *Cumulative results are as shown in the following table.*

Part 13.b. DF = 20, Heading and Speed -”MB” Field

Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
“MB” Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
Data: / **Item #**	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
1	1	1	01 0101 0101	1	10 1010 1010	1	01 1110 0010	1	0	1 0101 0101	1	0	1 0101 0101
2	1	0	10 1010 1010	1	01 0101 0101	1	01 0101 0101	1	1	0 1010 1011	1	1	0 1010 1011
3	1	1	11 0111 0111	1	11 0111 0111	1	11 0111 0111	1	1	1 0111 0111	1	1	1 0111 0111
4	1	0	11 1011 1011	1	11 1011 1011	1	11 1011 1011	1	1	1 1011 1011	1	1	1 1011 1011
5	1	1	01 1101 1101	1	01 1101 1101	1	01 1101 1101	1	0	1 1101 1101	1	0	1 1101 1101
6	1	1	10 1110 1110	1	10 1110 1110	1	10 1110 1110	1	1	0 1110 1110	1	1	0 1110 1110
7	1	1	11 1111 1111	1	11 1111 1111	1	11 1111 1111	1	1	0 0000 0000	1	1	0 0000 0000
8	1	0	00 0000 0000	1	00 0000 0000	1	00 0000 0000	1	0	1 1111 1111	1	0	1 1111 1111
9	1	0	01 0101 0111	1	01 0101 0111	1	01 0101 0111	1	0	1 1101 1101	1	0	1 1101 1101
10	1	0	01 0101 0101	1	01 0101 0101	1	01 0101 0101	1	0	1 1101 1101	1	0	1 1101 1101
11	0	0	00 0000 0000	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	0	0 0000 0000

2.7.7.14 Part 14 – Reduced Update Rate (§2.2.25.8.3)

Notes:

1. *The primary intent of Part 3 beyond data validation in Register 60_{16} is to validate Declaration of Capability as data inputs are reduced to rates that are less than the minimum acceptable rate.*
2. *Review all subparagraphs of Part 3 prior to performing tests. This is necessary to establish the appropriate timing between changing data inputs and interrogations.*

a. **Data / Source Change - Set 1:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)

Via an appropriate input interface, set the rate at which valid Magnetic Heading data is provided to less than once in 2.6 seconds.

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)

Via an appropriate input interface, set the rate at which valid Indicated Airspeed data is provided to less than once in 2.6 seconds.

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)

Via an appropriate input interface, set the rate at which valid Mach data is provided to less than once in 2.6 seconds.

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)

Via an appropriate input interface, set the rate at which valid Barometric Altitude Rate data is provided to less than once in 2.6 seconds.

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)

Via an appropriate input interface, set the rate at which valid Inertial Vertical Rate data is provided to less than once in 2.6 seconds.

b. **Register 60_{16} Capability Verification:** (§2.2.25.8 through §2.2.25.8.3)

Within 1.3 seconds of providing the transponder with data as detailed in Part 2.a, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC” =**	**“RR” =**	**“DI” =**	**“IIS” =**	**“RRS =**	**“X” =**	**“LOS” =**	**“XX” =**	**“TMS” =**
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Notes:

1. *The transponder should initiate the “B” timer for 18 ±1.0 seconds since a Comm-B Broadcast is initiated.*

2. *In this case, the Comm-B Broadcast is caused by the contents of Register 60_{16} changing as provision of all parameter data has effectively been terminated. This change causes a change to Register 17_{16}, which then forces a change to Register 10_{16}, which then results in the initiation of the Comm-B Broadcast.*

(1). Verify that the transponder replies with a DF=20 reply.

(2). During replies to this interrogation sequence and subsequent interrogations during this test procedure, monitor the “DR” field. If the “DR” field changes to 4, 5, 6, or 7, then the transponder has initiated a Comm-B Broadcast.

When the “DR” field changes, start a Test Timer to monitor that the “B”-Timer runs for 18 ±1.0 seconds.

“DR” = 4 or 5 if TCAS Information IS NOT available
= 6 or 7 if TCAS Information IS available.

(3). Verify that the “DF”=20 reply “MB” field provides Data with:

Part 2.b.(3) DF = 20, Heading and Speed ”MB” Field													
Reply Bits:	33	34	35 ---------- 44	45	46 ---- 55	56	57 -------- 66	67	68	69 ------- 77	78	79	80 ---------- 88
“MB” Bits:	1	2	3 ----------- 12	13	14 ----- 23	24	25 -------- 34	35	36	37 ------- 45	46	47	48 --------- 56
Field:	**Magnetic Heading**			**Indicated Airspeed**		**Mach**		**Barometric Altitude Rate**			**Inertial Vertical Rate**		
	Status	Sign	Data	Status	Data	Status	Data	Status	Sign	Data	Status	Sign	Data
Data:	0	0	00 0000 0000	0	00 0000 0000	0	00 0000 0000	0	0	0 0000 0000	0	0	0 0000 0000

c. **<u>Common Usage GICB Capability Report, Register 17$_{16}$:</u>** (§2.2.25.2.2.6 and §2.2.25.2.2.7)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 17$_{16}$ Common Usage GICB Capability Report:

REGISTER 17$_{16}$ COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**7**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 56 (bit 24 of the “MB” field) set to “0” to indicate that Register 60$_{16}$ servicing capability has been changed as data for Register 60$_{16}$ has been terminated.

d. **<u>Mode S Specific Services GICB Capability, Register 18$_{16}$:</u>** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 18$_{16}$ Mode S Specific Services GICB Capability:

REGISTER 18$_{16}$ MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**8**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). Bit 64 (bit 32 of the “MB” field) set to “1” to indicate that Register 19$_{16}$ servicing capability has been established during the power-on cycle.

(2). Bit 65 (bit 33 of the “MB” field) set to “1” to indicate that Register 18$_{16}$ servicing capability has been established during the power-on cycle.

(3). Bit 66 (bit 34 of the “MB” field) set to “1” to indicate that Register 17$_{16}$ servicing capability has been established during the power-on cycle.

e. **Mode S Specific Services GICB Capability, Register 19_{16}:** (§2.2.25.3)

Within FIVE (5) seconds of the interrogation / reply sequence in Part 3.b, interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 19_{16} Mode S Specific Services GICB Capability:

REGISTER 19_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**17** (11 HEX)	**7**	0	**9**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with Bit 49 (bit 17 of the “MB” field) set to “1” to indicate that Register 60_{16} servicing capability has been established during the power-on cycle.

f. **Comm-B Broadcast Validation:** (§2.2.25.1.4)

Continue to interrogate the transponder with the following GICB Extraction interrogation in order to extract the Register 60_{16} - Heading and Speed Report data monitor the “DR” field in the reply.

REGISTER 60_{16} HEADING AND SPEED REPORT GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**22** (16 HEX)	**7**	0	**0**	0	0	0	0

Within 67 seconds of providing the transponder with data as detailed in Part 2.a, verify that the “DR” field in DF=20 replies is set to DR=4, 5, 6, or 7 to indicate that a Comm-B Broadcast is active.

g. **Comm-B Broadcast Extraction:** (§2.2.25.1.4)

After determining that the “DR” field has been set to DR=4, 5, 6, or 7 in Part 3.f, interrogate the transponder with the following Comm-B Extraction interrogation in order to extract the Comm-B broadcast message which should be the Data Link Capability Report contained in Register 10_{16}.

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP									
1 ---- 5	6 ---- 8	9 --- 13	14 - 16	17 -- 20	21 -- 24	25	26	27—28	29 --- 32
				“SD”					
“UF” =	**“PC”** =	**“RR”** =	**“DI”** =	**“IIS”** =	**“RRS** =	**“X”** =	**“LOS”** =	**“XX”** =	**“TMS”** =
4	0	**16** (10 HEX)	**7**	0	**0**	0	0	0	0

Verify that the transponder replies with a DF=20 reply with:

(1). "DR" = 4 or 5 if TCAS Information IS NOT available

= 6 or 7 if TCAS Information IS available.

(2). Bits 33 - 40 (bits 1 - 8 of the "MB" field) set to 10 HEX (0001 0000).

(3). Bit 57 ["Mode S Specific Services Capability" (bit 25 of the "MB" field)] set to ONE (1) to indicate that the transponder has established Mode S Specific Services Capability.

(4). Bit 67 ["SIC" subfield (bit 35 of the "MB" field)] set to ONE (1) to indicate that the transponder does have "SI" capability.

(5). Bit 68 [Common Usage GICB Capability Report Bit (bit 36 of the "MB" field)] toggled to "0" (from "1") to indicate that Register 17_{16} has changed.

h. **<u>Comm-B Broadcast because of Data Link Capability Change Termination:</u>** (§2.2.25.1.4)

Continue to interrogate the transponder with the interrogation described in Part 3.g, (e.g., the last step) until the transponder replies with a DF=20 reply with "DR" NOT EQUAL to 4, 5, 6, or 7.

Verify that the elapsed time of the Test Timer started in Part 3.b.(2) is 18 ±1 second.

<u>Note:</u> *At this time, the "B" timer started in Part 3.b.(2), as broadcast because of a change in Data Link Capability, should have terminated.*

2.7.7.15 Part 15 – Multiple Data Sources (§2.2.25 through §2.2.25.4, and §2.2.25.8)

If Multiple Data Sources of Register 60_{16} parameters are provided to the Unit-Under-Test (UUT), then REPEAT all applicable sections of Part 2 for each additional data source that was not tested while performing Parts 1 through 13 above.

<u>Note:</u> *GPS Data Sources may not provide data more often than once every 1.2 seconds. If GPS Data Sources are used to provide data, ensure that the data is provided at the minimum rate of once every 1.2 seconds. For Register 60_{16}, this may apply to the Inertial Vertical Rate data.*

2.8 Generic Register XX Test Procedures (§2.2.26)

<u>Introduction:</u>

The following general test procedure is intended to provide guidelines for minimal verification that newly implemented GICB registers are properly being serviced.

2.8.1 Purpose and Definition (§2.2.26.1)

<u>Note:</u> *In the following subsections, "**ddd**" means the decimal equivalent to $\boldsymbol{XX_{16}}$. For instance, for 40_{16}, "**ddd**" = 64_{10} = 64.*

For any newly added given Register **XX_{16}**, refer to Appendix B, Table **B3-ddd** for appropriate format and definition of the Register.

2.8.2 Data Requirement (§2.2.26.2)

a. Ensure that no data is being provided to the transponder that could be used to fill any field in the Register **XX_{16}** that is being tested.

b. Interrogate the transponder using GICB protocols as specified in §2.2.19.1.12.3 (refers to §2.2.19.1.12.1 and §2.2.19.1.12.2).

Note 1: *See §2.7.7.1.a and b as example interrogations used to extract Register 60_{16}.*

c. Verify that the transponder replies with a DF=20 reply with Bits 33 through 88 (bits 1 through 56 of the "MB" field) set to ALL ZERO (0).

Note 2: *Some registers are required to fill bits 1 through 8 with the Register Number, e.g., **XX_{16}**. In such cases, bits 1 through 8 of the "MB" field will contain the Register number **XX_{16}** and the remaining bits (9 through 56) of the "MB" field will be set to ZERO (0).*

2.8.2.1 Data Field "y" (§2.2.26.2.1)

a. Via an appropriate interface, provide the transponder with appropriate valid data for each parameter "**y**" in Register **XX_{16}** that is to be tested.

b. Interrogate the transponder using GICB protocols as specified in §2.2.19.1.12.3 (refers to §2.2.19.1.12.1 and §2.2.19.1.12.2).

Note: *See §2.7.7.1.a and b as example interrogations used to extract Register 60_{16}.*

c. For each "**y**" parameter, verify that the transponder replies with an "MB" field having:

(1). Each "**y**" parameter encoded in the proper register location

(2). Each "**y**" parameter encoded in two's complement arithmetic unless otherwise specified.

(3). Each "**y**" parameter value properly rounded to preserve accuracy of ±½ LSB.

(4). Status bit for each applicable "**y**" parameter set to ONE (1) if data is valid and set to ZERO (0) if data is invalid.

2.8.3 Update Rate (§2.2.26.3)

Change the data provided to the transponder and repeat the interrogation given in §2.8.2.1.b as necessary to complete the following steps:

a. For each "**y**" parameter, verify that the data changes to the appropriate value required in §2.8.2.1.c within the maximum update interval time specified in Appendix B, Table B-2-1 for the given Register **XX_{16}** being tested.

b. If the appropriate value required in "a" above cannot be realized within twice the maximum update interval time specified or 2 seconds (whichever is greater), verify that the parameter "**y**" subfield and its associated status bit is set to ALL ZERO (0).

2.8.4 Service Reporting (§2.2.26.4)

Change the data provided to the transponder and repeat the interrogation given in §2.8.2.1.b as necessary to complete the following steps:

a. Verify that the servicing of Register $\mathbf{XX_{16}}$ during the power-on cycle of the transponder is properly reported in Registers 18_{16} through $1C_{16}$ as required in Appendix B, Table B-3-24 to Table B-3-28.

b. Verify that the real-time (not just since power-on) servicing of Register $\mathbf{XX_{16}}$ is properly reported in Register 17_{16} (see Appendix B, Table B-3-23) if such reporting is required for Register $\mathbf{XX_{16}}$.

c. Verify that an appropriate Comm–B Broadcast is initiated if a change to Register $\mathbf{XX_{16}}$ forces a change to Register 10_{16}.

Note: *See §2.7.7.2.b.(2) as an example of validating presence of the Broadcast using Register 60_{16}.*

d. Extract the Broadcast and verify that the contents of Register 10_{16} have been changed in accordance with the change action affecting Register $\mathbf{XX_{16}}$ under test.

Note: *See §2.7.7.2.g as an example of validating the Broadcast using Register 60_{16} as the register forcing the change to Register 10_{16}.*

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3 INSTALLED EQUIPMENT PERFORMANCE

3.1 Equipment Installation

3.1.1 Equipment Accessibility

Equipment controls and display(s) installed for in-flight operation **shall** be readily accessible from the normal seated position. The appropriate operator/crew members(s) **shall** have an unobstructed view of the display(s) when in the normal sitting position.

3.1.2 Inadvertent Turn Off

Appropriate controls **shall** be provided with adequate protection against inadvertent turn off.

3.1.3 Displays

All installed system displays **shall** be readily visible and readable from the crew member's normal position in all ambient lighting conditions for which system use is required.

Note: *Visors, glareshields or filters may be an acceptable means of obtaining daylight visibility.*

3.1.4 Aircraft Power Source

The voltage and voltage tolerance characteristics of the equipment **shall** be compatible with the aircraft power source of appropriate category as specified in RTCA/DO-160G.

3.1.5 Transmission Line(s)

The transmission line(s) connecting antenna(s) and transponder(s) **shall** have impedance, power handling and loss characteristics in accordance with the equipment manufacturer's specifications.

3.1.6 Antenna Location

a. Single Antenna

The antenna **shall** be installed on the bottom of the aircraft as close to the longitudinal axis of the aircraft as possible.

b. Diversity Transponder Installation

The top and bottom antennas **shall** be mounted as near as possible to the center line of the fuselage. Antennas **shall** be located so as to minimize obstruction to their fields in the horizontal plane.

Recommendation*: The horizontal distance between the top and bottom antennas should not be greater than 7.6 meters.*

Note: *This recommendation is intended to support the operation of any diversity transponder (including cables) with any diversity antenna installation and still satisfy the requirement of §3.1.6 c.*

c. Reply Delay of Diversity Transponders.

The total two-way transmission difference in mean reply delay between the two antenna channels (including the differential delay caused by transponder to antenna cables and the horizontal distance along the aircraft centerline between the two antennas) **shall not** exceed 0.130 microseconds for interrogations of equal amplitude. This requirement **shall** hold for interrogation signal strengths between MTL +3 dB and -21 dBm. The jitter requirements on each individual channel **shall** remain as specified for non-diversity transponders (see §2.2.4.2.5).

Note: *This requirement limits the total apparent jitter caused by antenna switching and by cable and antenna location delay differences.*

3.1.7 Mutual Suppression

If other equipment is installed in the aircraft operating at or near 1030 and 1090 MHz, such as DME, the need for mutual suppression **shall** be determined. When mutual suppression is used, the requirements of §2.2.11 **shall** be met.

3.2 Conditions of Test

The conditions of test stated in the following subparagraphs are applicable to the equipment tests specified in Subsection §3.3. Ground tests may be used for all tests specified.

3.2.1 Power Input

Tests may be conducted using either the aircraft's electrical power distribution system or an appropriate external power supply.

3.2.2 Interference Effects

With the equipment energized from the aircraft's electrical power generating system, individually operate each of the other electrically operated aircraft equipment and systems to determine that no significant conducted or radiated interference exists. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on at least the low, high and one mid-band frequencies. If appropriate, repeat tests using emergency power source(s).

3.2.3 Environment

During the tests, the equipment **shall not** be subjected to environmental conditions that exceed those in RTCA/DO-160G as specified by the equipment manufacturer.

3.2.4 Adjustment of Equipment

Circuits of the equipment under test **shall** be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests.

3.2.5 Warm-up Period

Unless otherwise specified, all tests **shall** be conducted after a warm-up period of not more than 15 minutes.

3.2.6 Radiation Pattern

The antenna **shall** have a radiation pattern which is essentially omnidirectional in the horizontal plane and have sufficient vertical beamwidth to assure proper equipment operation during normal aircraft maneuvers.

3.3 Test Procedures for Installed Equipment Performance

The test procedures set forth below are considered satisfactory in determining required installed equipment performance. Testing requirements are stated, in a manner that will make maximum use of bench test data while limiting flight tests to those requirements which cannot be tested conveniently by other means. Although suggested test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if the installing activity can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

Installed equipment performance tests confirm surveillance functions. Data link functions will be dealt with in a future document.

Current U.S. operating regulations require tests similar to those described herein be performed bi-annually to ensure against deterioration of performance. Since equipment installation requires initial performance of these tests, they are included herein.

3.3.1 Conformity Inspection

Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices. Verify that all mechanical and electrical connections have been made properly and that the equipment has been installed and located in accordance with the manufacturer's recommendations.

3.3.2 Bench Tests

The equipment **shall** have been tested and certified by the equipment manufacturer to demonstrate compliance with the minimum requirements stated in Section §2.0.

The transponder tests required below may be conducted using portable test equipment.

3.3.3 Reply Frequency

Interrogate the installed transponder and verify that the reply frequency of the system is 1090 ±1 MHz.

3.3.4 Framing Pulse Spacing

Verify that the time interval between the leading edges of the two framing pulses is 20.3 ±0.10 microseconds.

3.3.5 Reply Codes

a. Verify that all Mode 3/A reply pulses listed below are present.

Pulse	Position (microseconds)	4096 code for this pulse only
F1	0.00	
C1	1.45	0010
A1	2.90	1000
C2	4.35	0020
A2	5.80	2000
C4	7.25	0040
A4	8.70	4000
B1	11.60	0100
D1	13.05	0001
B2	14.50	0200
D2	15.95	0002
B4	17.40	0400
D4	18.85	0004
F2	20.30	
SPI	24.65	

b. Interrogate the transponder a sufficient number of times to verify that the correct 4096 code is transmitted. Use more than one 4096 code.

3.3.6 Pressure Altitude Transmissions

a. Verify that the transponder response to Mode C interrogations consists only of framing pulses F1 and F2. If complete altitude reporting capability is provided, the altitude digitizer may not be connected to the transponder at the time of the test.

b. Verify that the transponder response to Mode C interrogations consists of only framing pulses F1 and F2 with the altitude switch in the “OFF” position.

3.3.7 Altitude Reporting Test

a. A sufficient number of test points **shall** be checked to ensure that the altitude reporting equipment and transponder perform their intended function through their entire range while ascending or descending. Tests of each altitude code segment of the encoder (2300, 2500, 3800, 4300, 4800, 6800, 14800 and 30800 if available) are sufficient to ensure proper operation of each altitude code segment of the encoder.

b. Verify that the correspondence value of the altimeter system is 125 feet or less.

3.3.8 Reply Pulse Width

Verify that the duration of the F1 and F2 pulses between the 0.5 amplitude points on the leading and trailing edge is 0.45, ±0.10 microsecond with the transponder replying on Mode 3/A, code 0001, and code 7477.

3.3.9 Receiver Sensitivity

a. Verify that for ATCRBS interrogations the receiver sensitivity of the system at the antenna end of the transmission line is -73, ±4 dBm.

b. Verify that for Mode S P_6 type interrogations the sensitivity of the equipment at the antenna end of the transmission line is -74 dBm, ±3 dB.

3.3.10 Transmitter Power Output

a. Verify that transponders operating at altitudes above 15000 feet and/or at normal cruising speeds in excess of 175 knots have a peak pulse power at the antenna end of the transmission line of at least +21 dBW and not more than +27 dBW.

b. Verify that transponders intended for operation at altitudes not above 15000 feet have a peak pulse power at the antenna end of the transmission line of at least +18.5 dBW and not more than +27 dBW.

3.3.11 Mode S Address

Verify that the 24-bit discrete address transmitted in the Mode S squitter is the Mode S address that has been assigned to this aircraft. (See Advisory Circular 20-131A for information regarding Mode S address assignment.)

3.3.12 Received Reply

Interrogate the equipment with its discrete address and verify received reply.

3.3.13 Airspeed Fixed Field

Interrogate the equipment to confirm the maximum airspeed report.

3.3.14 On-the-Ground Condition

Verify that the equipment correctly reports the "on-the-ground" condition. If it is feasible to simulate the airborne condition, verify that the equipment correctly reports an "airborne" condition.

Also verify that when the unit is in the "on-the-ground" condition, the transponder generates Mode S squitters and replies to discretely-addressed Mode S interrogations (UF=0, 4, 5, 16, 20, 21, 24), but does not reply to ATCRBS, ATCRBS/Mode S All-Call or Mode S-Only All-Call interrogations.

If the unit is in the airborne condition, verify that the transponder generates Mode S squitters and replies to ATCRBS, ATCRBS/Mode S All-C all or Mode S-Only All-Call and discretely-addressed Mode S interrogations (UF=0, 4, 5, 16, 20, 21, 24).

3.3.15 Diversity Antenna Installations

Verify that the antennas on the aircraft are no more than 7.6 meter (25 feet) apart in the horizontal plane. The cables **shall** be essentially of equal electrical length.

3.4 Flight Test Procedures

This guidance material offers examples of flight test procedures for demonstration of selected performance functions. Flight demonstration of installed performance may be required by the aircraft operator or by airworthiness inspection agencies.

A schedule must be arranged with the area air traffic control facility so that a controller is available to observe the transponder reply and communicate with the test aircraft to confirm performance of the transponder.

Select a test area such that line-of-sight signal propagation is assured. Test maneuvers may include standard rate turns through 360 degrees, climbs and descents so that ATC can confirm valid return through normal flight attitudes. Verification of Ident codes selected and reported altitude response to Mode C should be checked.

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Production of RTCA DO-181E and EUROCAE ED-73E was a joint effort of RTCA Special Committee 209 and EUROCAE Working Group 49. Members who participate individually in both organizations are only listed once in their primary organization.

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for
Air Traffic Control Radar Beacon Systems/Mode Select
(ATCRBS/Mode-S)
Airborne Equipment

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Appendix A
Acronyms & Definition of Terms

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A. Acronyms & Definition of Terms

A.1 Acronyms

AA – Address Announced

AC – Advisory Circular

ACARS – Aircraft Communications, Addressing and Reporting System

ACAS – Airborne Collision Avoidance System

ACR – Adjacent Channel Reduction

ACS – Altitude Code Subfield

ADS – Automatic Dependent Surveillance

ADS-B – Automatic Dependent Surveillance Broadcast

AGL – Above Ground Level

AICB – Air Initiated Comm-B

AIS – Aircraft Identification Subfield

AP – Address Parity

APDU – Application Protocol Data Unit

AQ – Acquisition Special

ARA – Active Resolution Advisory

ASA – Aircraft Separation Assurance

A/V – Aircraft/Vehicle

ATCRBS – Air Traffic Control Radar Beacon System

ATC – Air Traffic Control

ATM – Air Traffic Management

ATS – Air Traffic Services

ATIS – Automatic Terminal Information Service

BCD – Binary Coded Decimal

BCS – Comm-B Capability Subfield

BDS – Comm-B Data Selector

BER – Bit Error Rate

BNR – Binary Numbers

bps – Bits Per Second

BW – Bandwidth

C/A – Coarse Acquisition

CC – Crosslink Capability

CDS – C – Definition Subfield

CFS – Continuation Subfield

CL – Code Label

CPA – Closest Point of Approach

CNS – Communications, Navigation and Surveillance

CDTI – Cockpit Display of Traffic Information

CEFR – CDTI-based Electronic Flight Rules

CPDLC – Controller-Pilot Data Link Communications

CRC – Cyclic Redundancy Check

CW – Continuous Wave

dB – Decibel

dBm – Decibel with respect to 1 milliwatt

DDS – D – Definition Subfield

DELM – Downlink Extended Long Messages

DF – Downlink Format

DI – Designation Identification

DME – Distance Measuring Equipment

DOD – U.S. Department of Defense

DOP – Dilution Of Precision

DP – Data Parity

DPSK – Differential Phase Shift Keying

ECS – Extended Capability Subfield

EHS – Enhanced Surveillance

ELM – Extended Length Message

ELS – Elementary Surveillance

ELT – Emergency Locating Transmitter

EPU – Estimated Position Uncertainty

E/W – East/West

ERP – Effective Radiated Power

ETA – Estimated Time of Arrival

EUROCAE – European Organization for Civil Aviation Equipment

FAA – Federal Aviation Administration

FAR – Federal Aviation Regulation

FEC – Forward Error Correction

FIFO – First In First Out

FIS-B – Flight Information Services-Broadcast

FMS – Flight Management System

f0 – Nominal or Center Frequency

fpm – Feet Per Minute

FSD – Full Scale Deflection

FS – Flight Status

FSS – Flight Service Station

FTE – Flight Technical Error

GICB – Ground Initiated Comm-B

GNSS – Global Navigation Satellite System

GPS – Global Positioning System

h – Modulation Index

Hz – Hertz

I – Inquiry Mode

IAS – Indicated Airspeed

IC – Interrogator Code

ICAO – International Civil Aviation Organization

ID – Identification (4096 code)

IDS – Identification Designation Subfield

IFR – Instrument Flight Rules

II – Interrogator Identification

IIS – Interrogator Identification Subfield

ILS – Instrument Landing System

IMC – Instrument Meteorological Conditions

INS – Inertial Navigation System

I/O – Input and/or Output

ISI – Inter-Symbol Interference

ITU – International Telecommunication Union

JAA – Joint Aviation Authorities
JAR – Joint Aviation Requirements
JTIDS – Joint Tactical Information Distribution System (a.k.a. Link 16)

KE – Control ELM
kHz – Kilohertz

L1 – 1575.42 MHz (a navigation frequency associated with GPS)
LAAS – Local Area Augmentation System
LADGPS – Landing Area Differential GPS
LOS – Lockout Subfield
LSB – Least Significant Bit
LSS – Lockout Surveillance Subfield

MA – Message Field in Comm-A
MASPS – Minimum Aviation System Performance Standards
MB – Message Field in Comm-B
Mbps – Million Bits Per Second
MBS – Multisite Comm-B Subfield
MC – Message Field in Comm-C
MD – Message Field in Comm-D
ME – Message Extended Squitter
MES – Multisite ELM Subfield
MFD – Multi-Functional Display
MHz – Megahertz
MIDS – Multifunctional Information Distribution Systems
MOPS – Minimum Operational Performance Standards
ms – Milliseconds
MSB – Most Significant Bit
MSL – Minimum Signal Level
MSSS – Mode S Specific Services
MTBF – Mean Time Between Failure
MTE – Multiple Threat Encounter

MTL – Minimum Trigger Level

MU – Message Field in Comm-U

MV – Message Field in Comm-V

N – Number of transitions at "1" in DPSK modulation

NAS – U.S. National Airspace System

NAV – Navigation

NAVAID – Navigation Aid

NC – Number of C segments

ND – Number of D segments

NM – Nautical Mile

NOTAM – Notice to Airmen

N/S – North/South

ONE, ONEs – The affirmative value of a binary bit.

PAM – Pulse Amplitude Modulation

PC – Protocol

PI – Priority/Interrogator Identity

PIREP – Pilot Report

PPM – Parts Per Million

PPS – Pulse Per Second

Pr – Probability of Receipt

PSR – Primary Surveillance Radar

PUME – Probability of Undetected Message Error

QFE – Aviation "Q" Code for "Field Elevation"

QNE – Aviation "Q" Code for "Nautical Height" for Enroute

QNH – Aviation "Q" Code for "Nautical Height"

RA – Resolution Advisory

RAC – Resolution Advisory Complement

RAI – Resolution Advisory Indicator

RAIM – Receiver Autonomous Integrity Monitoring

RAT – Resolution Advisory Terminated Indicator

RC – Reply Control

RCP – Required Communication Performance

RCS – Rate Control Subfield

RF – Radio Frequency

RI – Reply Information

RL – Reply Length

rms – Root Mean Square

RNP – Required Navigation Performance

RR – Reply Request

RRS – Reply Request Subfield in SD

RSP – Required System Performance

rss – Root Sum Square

RVSM – Reduced Vertical Separation Minimum

SA or S/A – Selective Availability

SAE – Standard Aerospace Equipment

SAR – Search And Rescue

SARPs – Standards and Recommended Practices

SAS – Surface Antenna Subfield

SD – Special Designation

SI – Surveillance Identifier

SID – Standard Instrument Departure

SIS – Surveillance Identifier Subfield

SL – Sensitivity Level

SLC – Sensitivity Level Control

SLS – Side Lobe Suppression

SNR – Signal-to-Noise Ratio

SPI – Special Position Identification

SPR – Sync Phase Reversal

SPS – Standard Positioning Service

SSE – Mode S Specific Services Entity

SSR – Secondary Surveillance Radar

SUA – Special Use Airspace

TA – Traffic Advisory

TACAN – Tactical Air Navigation

TAS – True Airspeed

TCAS/TCAS II – Traffic Alert and Collision Avoidance System

TCS – Type Control Subfield

TERPS – Terminal Instrument Procedures

TID – Threat Identity Data

TIDA – Threat Identity Data, Altitude

TIDB – Threat Identity Data, Bearing

TIDR – Threat Identity Data, Range

TIS – Traffic Information Service

TIS-B – Traffic Information Service-Broadcast

TMA – Terminal Maneuvering Area

TMS – Tactical Message Subfield

TOMR – Time of Message Receipt

TOMT – Time of Message Transmission

TRS – Transmission Rate Subfield

TSD – Traffic Situation Display (see also CDTI)

TSE – Total System Error

TSO – Technical Standards Order

TTI – Threat Type Indicator

UDS – U-Definition Subfield

UELM – Uplink Extended Length Message

UF – Uplink Format

UM – Utility Message

U.S. – United States

UTC – Coordinated Universal Time

UUT – Unit Under Test

VDS – V-Definition Subfield

VFR – Visual Flight Rules

VMC – Visual Meteorological Conditions

VOR – VHF Omni-directional Range [navigation system]

VS – Vertical Status

VSWR – Voltage Standing Wave Ratio

W – Watts

WAAS – Wide Area Augmentation System

WGS 84 – World Geodetic System 1984

Xmt – Transmit

ZERO, ZEROs – The negation value of a binary bit.

μs – Microsecond

μsec – Microsecond

A.2 Definition of Terms

ACAS – The Airborne Collision Avoidance System (ACAS) is an aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders. In this document ACAS refers to ACAS II, which is equal to TCAS II, version 7 or higher.

Accuracy – A measure of the difference between the A/V position reported in the ADS-B message field as compared to the true position. Accuracy is usually defined in statistical terms of either 1) a mean (bias) and a variation about the mean as defined by the standard deviation (sigma) or a root mean square (rms) value from the mean. The values given in this document are in terms of the two-sigma variation from an assumed zero mean error.

Active Waypoint – A waypoint to or from which navigational guidance is being provided. For a parallel offset, the active waypoint may or may not be at the same geographical position as the parent waypoint. When not in the parallel offset mode (operating on the parent route), the active and parent waypoints are at the same geographical position.

ADS-B Broadcast and Receive Equipment – Equipment that can transmit and receive ADS-B messages. Defined as Class A equipment.

ADS-B Broadcast Only Equipment – Equipment that can transmit but not receive ADS-B messages. Defined as Class B equipment.

ADS-B Message – A modulated packet of formatted data which conveys information used in the development of ADS-B reports.

ADS-B Report – Specific information provided by the ADS-B user participant subsystem to external applications. Reports contain identification, state vector, and status/intent information. Elements of the ADS-B Report that are used and the frequency with which they must be updated will vary by application. The portions of an ADS-B Report that are provided will vary by the capabilities of the transmitting participant.

ADS-B Subsystem – The set of avionics or equipment that performs ADS-B functionality in an aircraft or for ground-based, non-aircraft, participants.

ADS-B System – A collection of ADS-B subsystems wherein ADS-B messages are broadcast and received by appropriately equipped participant subsystems. Capabilities of participant subsystems will vary based upon class of equipage.

Advisory – An annunciation that is generated when crew awareness is required and subsequent crew action may be required; the associated color is unique but not red or amber/yellow. (Source: Advisory Circular AC 25-11).

Aircraft Address – The term "address" is used to indicate the information field in an ADS-B message that identifies the ADS-B unit that issued the message. The address provides a continent means by which ADS-B receiving units—or end applications—can sort messages received from multiple issuing units.

Aircraft/Vehicle (A/V) – Either (1) a machine or service capable of atmospheric flight, or (2) a vehicle on the airport surface movement area. In addition to A/Vs, ADS-B equipage may be extended to temporarily uncharted obstacles (i.e., obstacles not identified by a current NOTAM).

Air Mass – Air mass data includes barometric altitude and air speed.

Alert Zone – In the Free Flight environment, each aircraft will be surrounded by two zones, a protected zone and an alert zone. The alert zone is used to indicate a condition where intervention may be necessary. The size of the alert zone is determined by aircraft speed, performance, and by CNS/ATM capabilities.

Algorithm – A set of well-defined rules for the solution of a problem in a finite number of steps.

Along-Track Distance – The distance along the desired track from the waypoint to the perpendicular line from the desired track to the aircraft.

Applications – Specific use of systems that address particular user requirements. For the case of ADS-B, applications are defined in terms of specific operational scenarios.

Application Interface – The Application Interface is responsible for the extraction of ADS-B Reports from the Report Output Storage Buffer via the Report to Application Interface. Requirements for the Application Interface and Report to Application Interface are to be specified in various Application Interface specifications and therefore are not addressed in this document.

Barometric Altitude – Geopotential altitude in the earth's atmosphere above mean standard sea level pressure datum surface, measured by a pressure (barometric) altimeter.

Barometric Altitude Error – For a given true barometric pressure, Po, the error is the difference between the transmitted pressure altitude and the altitude determined using a standard temperature and pressure model with Po.

Burst – A series of interrogations.

Call Sign – The term "aircraft call sign" means the radiotelephony call sign assigned to an aircraft for voice communications purposes. (This term is sometimes used interchangeably with "flight identification" or "flight ID"). For general aviation aircraft, the aircraft call sign is normally its national registration number; for airline and commuter aircraft, it is usually comprised of the company name and flight number (and therefore not linked to a particular airframe); and for the military, it usually consists of numbers and code words with special significance for the operation being conducted.

Cancellation – This is a protocol used by the ADLP to cancel downlink messages that are queued in the transponder awaiting extraction by the Mode S ground system.

Caution – An annunciation that is generated when immediate crew awareness is required and subsequent crew action will be required; the associated color is amber/yellow. (Source: Advisory Circular AC 25-11).

Closeout – This is a protocol that confirms to a transponder that Comm-B, Comm-C (ELM) or Comm-D (ELM) transactions have been successfully completed and must be cleared from the transponder.

Closest Point of Approach (CPA) – The minimum horizontal distance between two aircraft during a close proximity encounter, a.k.a. miss distance.

Cockpit Display of Traffic Information (CDTI) – A function which provides the pilot/flight-crew with surveillance information about other aircraft, including their position. The information may be presented on a dedicated multi-function display (MFD), or be processed for presentation on existing cockpit flight displays. Traffic information for the CDTI function may be obtained from one or multiple sources (including ADS-B, TCAS, and TIS) and it may be used for a variety of purposes. Requirements for CDTI information will be based on intended use of the data (i.e., application).

Collision Avoidance – An unplanned maneuver to avoid a collision.

Conflict – Any situation involving two or more aircraft, or an aircraft and an airspace, or an aircraft and ground terrain, in which the applicable separation minima may be violated.

Conflict Detection – The process of projecting an aircraft's trajectory to determine whether it is probable that the applicable separation minimum will not be maintained between the aircraft and either 1) another aircraft or vehicle, 2) a given airspace, or 3) ground terrain. The level of uncertainty in the projection is reduced with increased knowledge about the situation, including aircraft capabilities, flight plan, short term intent information, etc.

Conflict Management – Process of detecting and resolving conflicts.

Conflict Probe – The flight paths are projected to determine if the minimum required separation will be violated. If the minima are not [projected to be] violated, a brief preventive instruction will be issued to maintain separation. If the projection shows the minimum required separation will be violated, the conflict resolution software suggests an appropriate maneuver.

Conflict Resolution – The process of identifying a maneuver or set of maneuvers that, when followed, do not cause a conflict or reduce the likelihood of conflict between an aircraft and either 1, another aircraft or vehicle, 2, a given airspace, or 3, ground terrain. Maneuvers may be given to multiple aircraft to fully resolve a conflict.

Conformance – The condition established when the surveillance report of an aircraft's position at some time "t" (established by the Automated Tracking function) is within the conformance region constructed around that aircraft at its nominal position at time "t", according to the agreed upon trajectory.

Cooperative Separation – This concept envisions a transfer of responsibility for aircraft separation from ground based systems to the air-crew of appropriately equipped aircraft, for a specific separation function such as In-trail merging or separation management of close proximity encounters. It is cooperative in the sense that ground-based ATC is involved in the handover process, and in the sense that all involved aircraft must be appropriately equipped, e.g., with RNAV and ADS-B capability, to perform such functions.

Co-ordinated Time Scales – A time scale synchronised within stated limits to a reference time scale. Co-ordinated Universal Time (UTC) is the time scale maintained by Bureau International des Poids et Mesures (BIPM), and the International Earth Rotation Service (IERS), which forms the basis of a co-ordinated dissemination of standard frequencies and time signal. It corresponds exactly in the rate with the International Atomic Time (TAI), but differs from it by an integer number of seconds.

Cross-link – A cross-link is a special purpose data transmission mechanism for exchanging data between two aircraft — a two-way addressed data link. For example, the TCAS II system uses a cross-link with another TCAS II to coordinate resolution advisories that are generated. A cross-link may also be used to exchange other information that is not of a general broadcast nature, such as intent information.

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

Desired Course – Can be either (1) True: A predetermined desired course direction to be followed (measured in degrees from true north), or (2) Magnetic: A predetermined desired course direction to be followed (measured in degrees from local magnetic north).

Diversity – A method of selecting the reply transmission path based on the relative amplitude of the received interrogation signal from two or more channels with independent antennas.

Downlink – A signal propagated from the transponder.

Dynamic Range – The ratio between the overload level and the minimum triggering level in a transponder.

Effective Update Interval – The time interval between successful message receipt with at least 98% probability of successful reception. For example, if

ADS-B messages are sent at one second intervals in signal-to-noise conditions with 75% probability of success per transmission, then the probability of obtaining at least one message in three tries is = 1.0 - $(0.25)^3$ ~ 98.4%. Thus the effective update interval for this case = 1 seconds x 3 = 3 seconds.

Effective Update Rate – The reciprocal of effective update interval, e.g., rate = 1/3 ~ 0.33 Hz for the example above.

En Route – A phase of navigation covering operations between departure and termination phases. En route phase of navigation has two subcategories: en route domestic/continental and en route oceanic.

Event-Driven – Messages that are broadcast periodically for a duration of the operational condition. Examples of Event-Driven Messages include the Extended Squitter Aircraft Status Message with the Emergency/Priority Status and TCAS RA subtypes (ref. RTCA DO-260B / EUROCAE ED-102A).

Field – A group of bits in a message treated as a single unit of information.

Format – The specific order in which fields of information appear in a Mode S digital message transmission.

Framing Pulse – One of the two pulses F_1 and F_2 spaced a nominal 20.3 μs apart which bracket a reply to Mode A and Mode C interrogations.

Format – The specific order in which fields of information appear in a Mode S digital message transmission.

FRUIT – Transponder replies unsynchronized in time. See Garble, Non-synchronous.

Garble, Non-synchronous – Reply pulses received from a transponder that is being interrogated from some other source. Also called FRUIT.

Geometric Dilution of Position (GDOP) – The ratio of position error of a multi-lateration system. More precisely, it is the ratio of the standard deviation of the position error to the standard deviation of the measurement errors, assuming all measurement errors are statistically independent and have a zero mean and the same standard distribution. GDOP is the measure of the "goodness" of the geometry of the multi-lateration sources as seen by the observer; a low GDOP is desirable, a high GDOP undesirable. (See also PDOP, HDOP and VDOP.)

Geometric Height – The minimum altitude above or below a plane tangent to the earth's ellipsoid as defined by WGS84.

Geometric Height Error – Geometric height error is the error between the true geometric height and the transmitted geometric height.

Global Navigation Satellite System (GNSS) – GNSS is a world wide position, velocity, and time determination system, that includes one or more satellite constellations, receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance for the actual phase of operation.

Global Positioning System (GPS) – A space based positioning, velocity and time system composed of space, control and user segments. The space segment, when fully operational, will be composed of 24 satellites in six orbital planes. The control segment consists of five monitor stations, three ground antennas and a master control station. The user segment consists of antennas and receiver processors that provide positioning, velocity, and precise timing to the user.

GNSS Altitude (MSL) – The height of the aircraft (or of its GNSS antenna) above the *geoid*, which is the surface that represents mean sea level. The term geoid, as defined by the National Geodetic Survey's *Geodetic Glossary*, is the equipotential surface of the Earth's gravity field which best fits, in the least squares sense, mean sea level.

Graticule – A network of lines on a map representing geographic parallels and meridians.

Horizontal Dilution of Precision (HDOP) – The ratio of user referenced horizontal position error to measurement error of a multi-lateration system. (See GDOP for a more detailed description.)

International Atomic Time (TAI) – The time scale established by the Bureau International des Poids et Mesures (BIPM) on the basis of data from atomic clocks operating in several establishments conforming to the definition of the second, the unit of the time of the International System of Units (SI).

In-Trail Climb – In-trail climb (ITC) procedures enables trailing aircraft to climb to a more fuel-efficient or less turbulent altitude.

In-Trail Descent – In-trail descent (ITD) procedures enables trailing aircraft to descend to a more fuel-efficient or less turbulent altitude.

Latency – The latency of an ADS-B transmission is the time period from the time of applicability of the aircraft/vehicle position ADS-B report until the transmission of that ADS-B report is completed.

Latency Compensation – High accuracy applications may correct for system latency introduced position errors using ADS-B time synchronized position and velocity information.

Lockout – This is a protocol which provides a means of preventing a Mode S transponder from replying to 'All-Call' interrogations. See ICAO Annex 10 §3.1.2.6.9 for full information.

Message – An arbitrary amount of information whose beginning and end are defined or implied. In this document, the information content of the message fields MA, MB, MC, FlD, MU and MV.

Minimum Triggering Level (MTL) – The minimum input power level that results in a 90% reply ratio in the Mode A/C format or in the Mode S format if the interrogation signal has all nominal spacings and widths and if the replies are the correct replies assigned to the interrogation format.

Mode Select 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.

Monopulse – A radar system using a receiving antenna having two or more partially overlapping lobes in the radiation pattern. Sum and difference channels in the receiver compare the amplitudes or phases of the received signal.

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.

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.

Near Term – Near-term applications are defined as those that can be supported by an initial ADS-B implementation and that may be operationally feasible within the context of a current ATC system or the ATC systems of the near future.

Normal Maneuver – Any maneuvers within the aircraft's approved flight-loads envelope that does not exceed 60 degrees angle of bank, or results in an abrupt change in the aircraft's attitude or accelerations. Abrupt changes in accelerations are those that exceed the values shown below. *Note that g = acceleration of gravity = 9.8 m/s*^{2}.

Horizontal Acceleration	Vertical Acceleration	Total Jerk
0.58 g	0.5 g	0.25 g/s

Optimum Sampling Point – The point during the bit period at which the opening of the eye diagram (i.e., the minimum separation between positive and negative frequency offsets at very high signal–to-noise ratios) is maximized.

Periodic Status – Status Messages that are broadcast independently in the same manner as the Airborne Position, Surface Position, Airborne Velocity and Aircraft Identification Messages. Examples of Periodic Status Messages include the Target State and Status and the Aircraft Operational Status (ref. RTCA DO-260B / EUROCAE ED-102A).

Planned Primary Means – Use of ADS-B for Planned Primary Means will be possible for selected airspace operations based upon predictable conditions, e.g., GNSS constellation, type of operation, and extent of ADS-B equipage for participating aircraft. That is, ADS-B will be available as a primary means of surveillance for particular periods of time in particular geographical regions for approved operations.

Phase of Flight – The phases of flight are defined as follows:

1. Oceanic/Remote – Radio updating is not viable due to either very limited navigation aid coverage or no navigation aid coverage.
2. En Route/Domestic – Aircraft sequences above 15500 feet while not actively flying a SID, or is above 15500 and sequences the last waypoint of a SID, or the phase of flight is Oceanic and radio updating is viable.
3. Terminal – Aircraft sequences below 15000 feet; or when the aircraft is in Approach and exceeds 3000 feet above arrival airport elevation if there is no missed approach holding point, or the missed approach holding point is sequenced; or the aircraft is in Takeoff and exceeds 3000 feet above departure airport elevation if no SID exist in active flight plan, or the last waypoint of the SID is sequenced below 15500.
4. Approach – The first waypoint on the active approach or approach transition is sequenced, or the aircraft sequences below 2000 feet above arrival airport elevation. Approach flight phase will not be active when a VFR approach is in the active flight plan.

Power Off Condition – The condition in which the transponder electrical power is not applied to the receiver, transmitter or related components.

Primary Means of Navigation – The airborne navigation equipment that meets the requirements of radio navigation for the intended phase of flight (route to be flown). These requirements include satisfying the necessary level of accuracy, integrity, continuity, and availability for a particular area, route, procedure, or operation. Examples of systems which provide a primary means of navigation include:

a. VOR for domestic en route, terminal, and non precision approach where it is available;
b. VOR/DME for domestic en route above flight level 240, terminal, and non precision approach where it is available;
c. OMEGA for Oceanic Operation;
d. INS for Oceanic Operation;

Protected Zone – In the Free Flight environment, each aircraft will be surrounded by two zones, a protected zone and an alert zone. The protected zone must remain sterile to assure separation. It can be envisioned as a distance-based “hockey puck” with radius equal to half the horizontal separation minimum and vertical extent equal to + half the vertical separation minimum. The size of the protected zone is a direct reflection of the position determination accuracy.

Protocol – A set of conventions between communicating processes on the formats and contents of messages to be exchanged.

QFE – Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above the station, whether airborne or on the ground.

QNE – The barometric pressure used for the standard altimeter setting (29.92 inches Hg, 1013.25 hectopascals).

QNH – Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above mean sea level, whether airborne or on the ground.

Reliability – The probability of performing a specified function without failure under given conditions for a specified period of time.

Reply Ratio – The ratio of a number of replies to the number of interrogations that should cause a reply to be generated.

Resolution – The smallest increment reported in an ADS-B message field. The representation of the least significant bit (LSB) in an ADS-B message field.

Required Navigation Performance (RNP) – A measure of the navigation system performance within a defined airspace, route, or procedure, including the operating parameters of the navigation's systems used within that airspace. (Source: Adapted from the ICAO Separation Panel).

Seamless – A "chock-to-chock" continuous and common view of the surveillance situation from the perspective of all users.

Sensor – Synonym for interrogator.

Site – Synonym for interrogator.

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

Sole Means of Navigation – An approved navigation system for a given operation or phase of flight that must allow the aircraft to meet, for the operation or phase of flight, all four navigation system performance requirements: accuracy, integrity, availability, and continuity of service.

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).

Squitter – The transmission of a specified reply format at a minimum rate without the need to be interrogated.

Standby State – The condition in which transponder electrical power may be applied to the receiver, transmitter and related components but the transponder is disabled from transmitting. In this state the transponder does not reply to interrogations and does not squitter any information in any Mode A/C/S format.

Station-keeping – Station-keeping provides the capability for a pilot to maintain an aircraft's position relative to the designated aircraft. For example, an aircraft taxiing behind another aircraft can be cleared to follow and maintain separation on a lead aircraft. Station-keeping can be used to maintain a given (or variable) separation. An aircraft that is equipped with an ADS-B receiver could be cleared to follow an FMS or GNSS-equipped aircraft on a GNSS/FMS/RNP approach to an airport. An aircraft doing station-keeping would be required to have, as a minimum, some type of CDTI.

Supplemental Means of Navigation – An approved navigation system that can be used in controlled airspace of the NAS in conjunction with a sole means of navigation.

Tactical Parameters – Tactical information may be used to enhance the performance of designated applications. System designs should be flexible enough to support tactical parameters; however, it is not required to provide the parameters in all implementations.

Technical Acknowledgment – Acknowledgment by the recipient that a message was received without error, with no inference of the recipient's intended reaction to that message.

Terminal Area – A general term used to describe airspace in which approach control service or airport traffic control service is provided.

Total System Error (TSE) – Generic: The root sum square of the navigation source error, airborne component error, display error and flight technical error. Specific: The root-sum-square of the position fixing error, display error, course selection error and flight technical error.

Track Angle – Instantaneous angle measured from either true or magnetic north to the aircraft's track.

Transaction – The process of accepting and processing an interrogation and generating a corresponding reply.

Trigger – Detection of ADS-B or Ground Uplink synchronization sequence.

Universal Time (UT) – Universal Time is the general designation of time scales based on the rotation of the Earth.

Uplink – Signal propagated toward a transponder.

UTC (Co-ordinated Universal Time) – See co-ordinated time scales.

Velocity Uncertainty Category (VUC) – The velocity uncertainty category (VUC) is needed for surveillance applications to determine whether the reported velocity has an acceptable level of velocity uncertainty.

Vertical Profile – A line or curve, or series of connected lines and/or curves in the vertical plane, defining an ascending or descending flight path either emanating from or terminating at a specified waypoint and altitude, or connecting two or more specified waypoints and altitudes. In this sense, a curve may be defined by performance of the airplane relative to the air mass.

Warning – An annunciation that is generated when immediate recognition and corrective or compensatory action is required; the associated color is red. (Source: Advisory Circular AC 25-11)

World Geodetic Survey (WGS) – A consistent set of parameters describing the size and shape of the earth, the positions of a network of points with respect to the center of mass of the earth, transformations from major geodetic datums, and the potential of the earth (usually in terms of harmonic coefficients).

World Geodetic System 1984 – A set of quantities, developed by the U.S. Department of Defense for determining geometric and physical geodetic relationships on a global scale, based on a geocentric origin and a reference ellipsoid with semi-major axis 6378137 and flattening 1/298.257223563.

Appendix B
Aircraft Register Formats

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B. Aircraft Register Formats

B.1 Introduction

The purpose of this Appendix is to specify technical provisions for the definition for data/message formats of aircraft registers which can be extracted using Ground Initiated Comm-B (GICB) protocols, as defined in Appendix C. In addition, this Appendix includes implementation guidelines for registers that are utilized in support of Elementary and Enhanced Surveillance.

Note: *Appendix B is arranged in the following manner:*

Section B.1 Introduction
Section B.2 Data Formats for Transponder Registers
Section B.3 BDS Registers Tables
Section B.4 Implementing Guidance

B.2 Data Formats for Transponder Registers

B.2.1 Register Allocation

Applications shall use the allocated Register numbers as shown in the Table B-2-1. The details of the data to be entered into the assigned Registers are defined in §B.3. Table B-2-1 specifies the maximum update intervals at which the appropriate transponder Register(s) shall be reloaded with valid data. Any valid data shall be reloaded into the relevant Register field as soon as it becomes available at the Mode S Specific Services entity (SSE) interface, regardless of the update rate. If data is not available for a time no greater than twice the specified maximum update interval or 2 seconds (whichever is the greater), the status bit (if specified for that field) shall indicate that the data in that field is invalid and the field shall be ZEROed. The Register number shall be equivalent to the Comm-B data selector (BDS) value used to address that Register. The data link capability report (Register 10_{16}) shall be updated within one second of the data changing and at least every four (4) seconds thereafter.

Table B-2-1: GICB Register Number Assignments

Transponder Register No.	***Assignment***	***Maximum update interval (see Note 1)***
00_{16}	Not valid	N/A
01_{16}	Reserved	N/A
02_{16}	Linked Comm-B, segment 2	N/A
03_{16}	Linked Comm-B, segment 3	N/A
04_{16}	Linked Comm-B, segment 4	N/A
05_{16}	Extended Squitter Airborne Position	0.2s
06_{16}	Extended Squitter Surface Position	0.2s
07_{16}	Extended Squitter Status	1.0s
08_{16}	Extended Squitter Identification and Category	15.0s

Transponder Register No.	***Assignment***	***Maximum update interval (see Note 1)***
09_{16}	Extended Squitter Airborne Velocity	1.3s
$0A_{16}$	Extended Squitter Event-Driven Information	Variable
$0B_{16}$	Air/air information 1 (aircraft state)	1.3s
$0C_{16}$	Air/air information 2 (aircraft intent)	1.3s
$0D_{16} – 0E_{16}$	Reserved for air/air state information	To be determined
$0F_{16}$	Reserved for TCAS/ACAS	To be determined
10_{16}	Data Link Capability Report	$\leq$4.0s
$11_{16} – 16_{16}$	Reserved for extension to datalink capability reports	5.0s
17_{16}	Common usage GICB Capability Report	5.0s
$18_{16} – 1C_{16}$	Mode S Specific Services Capability Reports	§2.2.24.5.3
$1D_{16} – 1F_{16}$	Mode S Specific Services Capability Reports	5.0s
20_{16}	Aircraft Identification	5.0s
21_{16}	Aircraft and airline registration markings	15.0s
22_{16}	Antenna positions	15.0s
23_{16}	Reserved for antenna position	15.0s
24_{16}	Reserved for aircraft parameters	15.0s
25_{16}	Aircraft type	15.0s
$26_{16} – 2F_{16}$	Reserved	N/A
30_{16}	TCAS/ACAS Active Resolution Advisory	§2.2.22.1.2.1.3
$31_{16} – 3F_{16}$	Reserved	N/A
40_{16}	Selected vertical intention	1.0s
41_{16}	Next waypoint identifier	1.0s
42_{16}	Next waypoint position	1.0s
43_{16}	Next waypoint information	0.5s
44_{16}	Meteorological routine air report	1.0s
45_{16}	Meteorological hazard report	1.0s
46_{16}	Reserved for flight management system Mode 1	To be determined
47_{16}	Reserved for flight management system Mode 2	To be determined
48_{16}	VHF channel report	5.0s
$49_{16} – 4F_{16}$	Reserved	N/A
50_{16}	Track and turn report	1.3s
51_{16}	Position report coarse	1.3s
52_{16}	Position report fine	1.3s
53_{16}	Air-referenced state vector	1.3s
54_{16}	Waypoint 1	5.0s
55_{16}	Waypoint 2	5.0s
56_{16}	Waypoint 3	5.0s

Transponder Register No.	***Assignment***	***Maximum update interval (see Note 1)***
57_{16} – $5E_{16}$	Reserved	N/A
$5F_{16}$	Quasi-static parameter monitoring	0.5s
60_{16}	Heading and speed report	1.3s
61_{16}	Extended Squitter Aircraft Status	1.0s
62_{16}	Target State and Status Information	0.5
63_{16}	Reserved for Extended Squitter	N/A
64_{16}	Reserved for Extended Squitter	N/A
65_{16}	Extended Squitter Aircraft Operational Status	2.5 s
66_{16} – $6F_{16}$	Reserved for Extended Squitter	N/A
70_{16} – 75_{16}	Reserved for future aircraft downlink parameters	N/A
76_{16} – $E0_{16}$	Reserved	N/A
$E1_{16}$ – $E2_{16}$	Reserved for Mode S BITE	N/A
$E3_{16}$	Transponder type/part number	15 s
$E4_{16}$	Transponder software revision number	15 s
$E5_{16}$	TCAS/ACAS unit part number	15 s
$E6_{16}$	TCAS/ACAS unit software revision number	15 s
$E7_{16}$	Transponder Status and Diagnostics	15 s
$E8_{16}$	Reserved for Future Diagnostics	N/A
$E9_{16}$	Reserved for Future Diagnostics	N/A
EA_{16}	Vendor Specific Status and Diagnostics	15 s
EB_{16}	Reserved for Future Vendor Specific Diagnostics	N/A
EC_{16}	Reserved for Future Vendor Specific Diagnostics	N/A
ED_{16} – $F0_{16}$	Reserved	N/A
$F1_{16}$	Military applications	15 s
$F2_{16}$	Military applications	15 s
$F3_{16}$ – FF_{16}	Reserved	N/A

Notes:

1. *The term "minimum update rate" is used in this document. The minimum update rate is obtained when data is loaded in one Register field once every maximum update interval.*
2. *If Extended Squitter is implemented, then Register 08_{16} is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into the Register during the current power-on cycle. Register 08_{16} is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. (See §2.2.5.1.11.c in RTCA DO-260B / EUROCAE ED-102A). Refer to §B.4.3.3 for implementation guidelines regarding Register 08_{16} and 20_{16}.*

B.2.2 General Conventions on Data Formats

B.2.2.1 Validity of Data

The bit patterns contained in the 56-bit transponder Registers (other than Registers accessed by BDS Codes 0,2; 0,3; 0,4; 1,0; 1,7 to 1,C; 2,0 and 3,0) are considered as valid application data only if:

1) The Mode S Specific Services capability bit is set in Register 10_{16}. This is indicated by bit 25 being set to "ONE," and

2) The GICB service corresponding to the application is shown as "supported" by the corresponding bit in the GICB capability report Registers 17_{16} to $1C_{16}$ being set to "ONE," and

Notes:

1. The intent of the capability bits in Register 17_{16} is to indicate that useful data are contained in the corresponding transponder Register. For this reason, each bit for a Register is cleared if data becomes unavailable (see ICAO Doc 9871, §A.2.5.4.1) and set again when data insertion into the Register resumes.

2. A bit set in Registers 18_{16} to $1C_{16}$ indicates that the application using this Register has been installed on the aircraft. These bits are not cleared to reflect the real-time loss of an application, as is done for Register 17_{16} (see ICAO Doc 9871, §A.2.5.4.2).

3) The data value is valid at the time of extraction. This is indicated by a data field status bit (if specified for that field). When this status bit is set to "ONE" the data field(s) which follow, up to the next status bit, are valid. When this status bit is set to "ZERO", the data field(s) are invalid.

B.2.2.2 Representation of Numeric Data

Numerical data shall be represented as follows:

1) Numerical data are represented as binary numerals. When the value is signed, 2s complement representation shall be used, and the bit following the status bit are the sign bit.

2) Unless otherwise specified, whenever more bits of resolution are available from the data source than in the data field into which that data are to be loaded, the data are rounded to the nearest value that can be encoded in that data field.

Note: *Unless otherwise specified, it is accepted that the data source may have less bits of resolution than the data field.*

3) When the data source provides data with a higher or lower range than the data field, the data are truncated to the respective maximum or minimum value that can be encoded in the data field.

4) In all cases where a status bit is specified in the data field it shall be set to "ONE" to indicate VALID and to "ZERO" to indicate INVALID.

Notes:

1. *This facilitates partial loading of the registers.*
2. *VALID indicates that the data contained in the field, represents real operational information which can be used by the application. This facilitates partial loading of the registers.*
3. *As an example, where ARINC 429 data are used, the single status bit specified in the field is derived from ARINC 429 status bits 30 and 31 bits as follows:*
   a) *If bits 30 and 31 represent "Failure Warning, No Computed Data" then the status bit shall be set to "INVALID".*

   b) *If bits 30 and 31 represent "Functional Test" then the status bit shall be set to "INVALID".*

   c) *If bits 30 and 31 represent "Normal Operation," "plus sign," or "minus sign," then the status bit shall be set to "VALID" provided that the data are being updated at the required rate (§B.2.1).*

   d) *If the data are not being updated at the required rate (§B.2.1), then the status bit shall be set to "INVALID".*

5) When specified in the field, the switch bit indicates which of two alternative data types is being used to update the parameter in the transponder Register.

6) The bits in the MB field are numbered in the order of their transmission, beginning with bit 1. Unless otherwise stated, numerical values encoded by groups (fields) of bits are encoded using positive binary notation and the first bit transmitted is the most significant bit (MSB). Information will be coded in fields which consist of at least one bit.

7) Registers containing data intended for broadcast Comm-B have the broadcast identifier located in the eight most significant bits of the MB field.

Notes:

1. *When multiple data sources are available, the one with the highest resolution should be selected.*

2. *By default, values indicated in the range of the different fields of registers have been rounded to the nearest integer value or represented as a fraction.*

B.2.2.3 Representation of Alphanumeric Character Encoding

For Registers requiring alphanumeric character encoding, each character shall be coded as a 6-bit subset of the International Alphabet Number 5 (IA-5) as illustrated in Table B-2-2. The character code shall be transmitted with the high order unit (b6) first and the reported character string shall be transmitted with its left-most character first. Characters shall be coded consecutively without intervening SPACE code. Any unused character spaces at the end of the subfield shall contain a SPACE character code.

Table B-2-2: 6-Bit Subset of International Alphabet Number (IA-5) for Character Coding

				b6	0	0	1	1
				b5	0	1	0	1
b4	b3	b2	b1					
0	0	0	0			P	SP	0
0	0	0	1		A	Q		1
0	0	1	0		B	R		2
0	0	1	1		C	S		3
0	1	0	0		D	T		4
0	1	0	1		E	U		5
0	1	1	0		F	V		6
0	1	1	1		G	W		7
1	0	0	0		H	X		8
1	0	0	1		I	Y		9
1	0	1	0		J	Z		
1	0	1	1		K			
1	1	0	0		L			
1	1	0	1		M			
1	1	1	0		N			
1	1	1	1		O			

SP – SPACE Code

B.3 BDS Register Formats

The definitions of the Registers herein are in conformance with ICAO Document 9871, 2nd Edition. Tables are numbered B-3-X where "X" is the decimal equivalent of the BDS code Y,Z where Y is the BDS1 code and Z is the BDS2 code, used to access the data format for a particular Register. The following tables are not included in this section:

B-3-1
B-3-2 to B-3-4 (Used by the linked Comm-B protocol)
B-3-5 to B-3-6 (Reserved for extended squitter)
B-3-8 to B-3-10 (Reserved for extended squitter)
B-3-13 to B-3-14 (Reserved for air/air state information)
B-3-15 (Reserved for TCAS/ACAS)
B-3-17 to B-3-22
B-3-35 (Reserved for antenna position)

B-3-36 (Reserved for aircraft parameters)
B-3-38 to B-3-47
B-3-49 to B-3-63
B-3-68 to B-3-69 (Reserved for meteorological reports)
B-3-70 to B-3-71
B-3-73 to B-3-79
B-3-87 to B-3-94
B-3-99 to B-3-100 (Reserved for extended squitter)
B-3-102 to B-3-111 (Reserved for extended squitter)
B-3-112 to B-3-224
B-3-225 to B-3-226 (Reserved for Mode S BITE)
B-3-232 to B-3-233
B-3-235 to B-3-240
B-3-243 to B-3-255

For additional information on the following ADS-B Registers, please reference RTCA DO-260B / EUROCAE ED-102A:

Table B-3-5	BDS Code 0,5	Extended Squitter Airborne Position
Table B-3-6	BDS Code 0,6	Extended Squitter Surface Position
Table B-3-7	BDS Code 0,7	Extended Squitter Status (see *Note*)
Table B-3-8	BDS Code 0,8	Extended Squitter Aircraft Identification and Category
Table B-3-9a	BDS Code 0,9	Extended Squitter Airborne Velocity (Subtypes 1 and 2 – Velocity Over Ground)
Table B-3-9b	BDS Code 0,9	Extended Squitter Airborne Velocity (Subtypes 3 and 4 – Airspeed and Heading)
Table B-3-10	BDS Code 0,A	Extended Squitter Event-Driven Information
Table B-3-97-1	BDS Code 6,1	Extended Squitter Aircraft Status (Subtype = 1 – Emergency/Priority Status)
Table B-3-97-2	BDS Code 6,1	Extended Squitter Aircraft Status (Subtype = 2 – TCAS RA Broadcast
Table B-3-98	BDS Code 6,2	Target State and Status
Table B-3-101	BDS Code 6,5	Extended Squitter Aircraft Operational Status

Note: *The 1090 Extended Squitter Status Register is provided in this section since it is not squittered and is intended to be accessed through GICB protocols.*

Table B-3-7: BDS Code 0,7 – Extended Squitter Status

MB FIELD

1	MSB TRANSMISSION RATE
2	LSB SUBFIELD (TRS)
3	ALTITUDE TYPE SUBFIELD (ATS)
4–56	RESERVED

PURPOSE: To provide information on the capability and status of the extended squitter rate of the transponder.

Transmission rate subfield (TRS) shall be coded as follows:

0 = No capability to determine surface squitter rate
1 = High surface squitter rate selected
2 = Low surface squitter rate selected
3 = Reserved

Altitude type subfield (ATS) shall be coded as follows:

0 = Barometric altitude
1 = GNSS height (HAE)

Aircraft determination of surface squitter rate:

For aircraft that have the capability to automatically determine their surface squitter rate, the method used to switch between the high and low transmission rates shall be as follows:

a) Switching from high to low rate: Aircraft shall switch from high to low rate when the on-board navigation unit reports that the aircraft's position has not changed more than 10 meters in any 30 second interval. The algorithm used to control the squitter rate shall save the aircraft's position at the time that low rate is selected.

b) Switching from low to high rate: Aircraft shall switch from low to high rate as soon as the aircraft's position has changed by 10 meters or more since the low rate was selected.

For transponder-based implementations, the automatically selected transmission rate shall be subject to being overridden by commands received form the ground control.

Table B-3-11: BDS Code 0,B – Air-to-Air State Information 1 (Aircraft State)

MB FIELD

1	STATUS
2	MSB = 1024 knots
3	
4	
5	TRUE AIR SPEED
6	
7	
8	Range [0, 2047] knots
9	
10	
11	
12	LSB = 1.0 knot
13	SWITCH (0 = Magnetic heading 1 = True heading)
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	HEADING
19	
20	
21	Range [-180, +180] degrees
22	
23	
24	LSB = 360/1024 degrees
25	STATUS
26	SIGN
27	MSB = 90 degrees
28	
29	
30	
31	TRUE TRACK ANGLE
32	
33	
34	
35	
36	Range [-180, +180] degrees
37	
38	
39	
40	LSB = 360/32768 degrees
41	STATUS
42	MSB = 1024 knots
43	
44	
45	
46	GROUND SPEED
47	
48	
49	
50	
51	Range [0, 2048] knots
52	
53	
54	
55	LSB = 1/8 knot
56	RESERVED

PURPOSE: To report threat aircraft state information in order to improve the ability of TCAS/ACAS to evaluate the threat and select a resolution maneuver.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-12: BDS Code 0,C – Air-to-Air State Information 2 (Aircraft Intent)

MB FIELD

1	STATUS
2	MSB = 32768 feet
3	
4	
5	LEVEL OFF ALTITUDE
6	
7	
8	
9	Range [0, 65520] feet
10	
11	
12	
13	LSB = 16 feet
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	NEXT COURSE (TRUE GROUND TRACK)
19	
20	
21	Range [+180, -180] degrees
22	
23	
24	LSB = 360/1024 degrees
25	STATUS
26	MSB = 128 seconds
27	
28	TIME TO NEXT WAYPOINT
29	All ONEs = time exceeds 255 seconds
30	
31	
32	Range [0, 256] seconds
33	
34	LSB = 0.5 seconds
35	STATUS
36	SIGN
37	MSB = 8192 ft/min
38	
39	VERTICAL VELOCITY (UP IS POSITIVE)
40	
41	Range [-16384, +16320] ft/min
42	
43	
44	LSB = 64 ft/min
45	STATUS
46	SIGN
47	MSB = 45 degrees
48	
49	ROLL ANGLE
50	
51	Range [-90, 89] degrees
52	
53	LSB = 45/64 degrees
54	RESERVED
55	
56	

PURPOSE: To report threat aircraft state information in order to improve the ability of TCAS/ACAS to evaluate the threat and select a resolution maneuver.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-16: BDS Code 1,0 – Data Link Capability Report (§2.2.19.1.12.6)

MB FIELD

1	MSB
2	
3	
4	BDS Code 1,0
5	
6	
7	
8	LSB
9	Continuation flag (see 9)
10	
11	
12	RESERVED
13	
14	
15	Overlay Command Capability (OCC) (see 19)
16	Reserved for TCAS/ACAS (see 15)
17	
18	
19	
20	Mode-S subnetwork version number (see 12)
21	
22	
23	
24	Transponder enhanced protocol indicator (see 4)
25	Mode-S specific services capability (see 2)
26	
27	Uplink ELM average throughput capability (see 13)
28	
29	Downlink ELM: throughput capability of downlink ELM
30	Containing the maximum number of ELM segments that the
31	Transponder can deliver in response to a single requesting
32	Interrogation (UF = 24). (see 14)
33	Aircraft identification capability (see 11)
34	Squitter capability subfield (SCS) (see 5)
35	Surveillance identifier code (SIC) (see 6)
36	Common usage GICB capability report (see 7)
37	
38	RESERVED FOR TCAS/ACAS (see 16, 17 and 18)
39	
40	
41	MSB
42	
43	
44	
45	
46	
47	Bit array indicating the support status of DTE
48	subaddresses 0 to 15 (see 3 and 8)
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To report the data link capability of the Mode S transponder / data link installation.

The coding of this Register shall conform to:

1) ICAO Annex 10 Volume IV, §3.1.2.6.10.2 and §4.3.8.4.2.2.2.

2) When bit 25 is set to 1, it shall indicate that at least one Mode-S specific service (other than GICB services related to registers 02_{16}, 03_{16}, 04_{16}, 10_{16}, 17_{16} to $1C_{16}$, 20_{16} and 30_{16}) is supported and the particular capability reports shall be checked.

   Note: *Registers accessed by BDS Codes 0,2; 0,3; 0,4; 1,0; 1,7 to 1,C; 2,0 and 3,0 do not affect the setting of bit 25.*

3) Starting from the MSB, each subsequent bit position shall represent the DTE subaddress in the range from 0 to 15.

4) The enhanced protocol indicator shall denote a Level 5 transponder when set to 1, and a Level 2 to 4 transponder when set to 0.

5) The squitter capability subfield (SCS) shall be set to 1 if both Registers 05_{16} and 06_{16} have been updated within the last ten, plus or minus one, seconds. Otherwise, it shall be set to ZERO (0).

   Note: *Registers 05_{16} and 06_{16} are used for the extended squitter Airborne and surface position reports, respectively.*

6) The surveillance identifier code (SIC) bit shall be interpreted as follows:

   0 = no surveillance identifier code capability
   1 = surveillance identifier code capability

7) Bit 36 shall be toggled each time the common usage GICB capability report (Register 17_{16}) changes. To avoid the generation of too many broadcast capability report changes, Register 17_{16} shall be sampled at approximately one minute intervals to check for changes.

8) The current status of the on-board DTE shall be periodically reported to the GDLP by on-board sources. Since a change in this field results in a broadcast of the capability report, status inputs shall be sampled at approximately one minute intervals.

9) In order to determine the extent of any continuation of the data link capability report (into those registers reserved for this purpose: Register 11_{16} to Register 16_{16}), bit 9 shall be reserved as a continuation flag to indicate if the subsequent Register shall be extracted. For example: upon detection of bit 9 = 1 in Register 10_{16}, then Register 11_{16} shall be extracted. If bit 9 = 1, in Register 11_{16}, then Register 12_{16} shall be extracted, and so on (up to Register 16_{16}). Note that if bit 9 = 1 in Register 16_{16}, then this shall be considered as an error condition.

(Requirements are continued on the next page)

Table B-3-16: BDS Code 1,0 – Data Link Capability Report (concluded)

10) The Mode-S transponder may update bits 1-8, 16, 33, 35 and 37-40 independent of the ADLP. These bits are provided by the transponder when the data link capability report is broadcast as a result of a transponder detected change in capability reported by the ADLP (§3.1.2 of ICAO Annex 10 Volume IV).

11) Bit 33 indicates the availability of Aircraft Identification data. It shall be set by the transponder if the data comes to the transponder through a separate interface and not through the ADLP.

12) The Mode-S Subnetwork Version Number shall be coded as follows:

Version Number	ICAO	RTCA	EUROCAE
0	Mode-S subnetwork not available		
1	ICAO Doc 9688 (1996)		
2	ICAO Doc 9688 (1998)		
3	ICAO Annex 10, Vol III, Amendment 77		
4	ICAO Doc 9871, Edition 1	DO-181D	ED-73C
5	ICAO Doc 9871, Edition 2	DO-181E	ED-73E
6 - 127	Reserved		

13) Uplink ELM average throughput capability shall be coded as follows:
 0 = No UELM Capability
 1 = 16 UELM segments in 1 second
 2 = 16 UELM segments in 500 ms
 3 = 16 UELM segments in 250 ms
 4 = 16 UELM segments in 125 ms
 5 = 16 UELM segments in 60 ms
 6 = 16 UELM segments in 30 ms
 7 = Unassigned

14) Downlink ELM throughput capability shall be coded as follows:
 0 = No DELM Capability
 1 = One 4 segment DELM every second
 2 = One 8 segment DELM every second
 3 = One 16 segment DELM every second
 4 = One 16 segment DELM every 500 ms
 5 = One 16 segment DELM every 250 ms
 6 = One 16 segment DELM every 125 ms
 7-15 = Unassigned

15) Bit 16 shall be set to ONE (1) to indicate that the transponder TCAS interface is operational and the transponder is receiving TCAS RI=2, 3 or 4.

16) Bit 37 shall be set to ONE (1) to indicate the capability of Hybrid Surveillance, and set to ZERO (0) to indicate that there is no Hybrid Surveillance capability.

17) Bit 38 shall be set to ONE (1) to indicate that the TCAS is generating both TAs and RAs, and set to ZERO (0) to indicate the generation of TAs only.

18)

Bit 40	Bit 39	Meaning
0	0	DO-185 (6.04A)
0	1	DO-185A
1	0	DO-185B
1	1	Reserved for future versions

19) The Overlay Command Capability (OCC) in Bit 15 shall be interpreted as follows:
 0 = No Overlay Command Capability
 1 = Overlay Command Capability

Note: *Additional implementation guidelines are provided in §B.4.1 of this Appendix.*

Table B-3-23: BDS Code 1,7 – Common Usage GICB Capability Report

MB FIELD

1	0,5 Extended Squitter Airborne Position
2	0,6 Extended Squitter Surface Position
3	0,7 Extended Squitter Status
4	0,8 Extended Squitter Identification and Category
5	0,9 Extended Squitter Airborne Velocity Information
6	0,A Extended Squitter Event-Driven Information
7	2,0 Aircraft identification
8	2,l Aircraft registration number
9	4,0 Selected vertical intention
10	4,l Next waypoint identifier
11	4,2 Next waypoint position
12	4,3 Next waypoint information
13	4,4 Meteorological routine report
14	4,5 Meteorological hazard report
15	4.8 VHF channel report
16	5,0 Track and turn report
17	5,1 Position coarse
18	5,2 Position fine
19	5,3 Air-referenced state vector
20	5,4 Waypoint 1
21	5,5 Waypoint 2
22	5,6 Waypoint 3
23	5,F Quasi-static parameter monitoring
24	6,0 Heading and speed report
25	Reserved for aircraft capability
26	Reserved for aircraft capability
27	E,1 Reserved for Mode S BITE (Built In Test Equipment)
28	E,2 Reserved for Mode S BITE (Built In Test Equipment)
29	F,1 Military applications
30–56	RESERVED

PURPOSE: To indicate common usage GICB services currently Supported.

1) Each bit position shall indicate that the associated Register is available in the aircraft installation when set to ONE (1).

2) All Registers shall be constantly monitored at a rate consistent with their individual required update rate and the corresponding capability bit shall be set to ONE (1) only when valid data is being input to that Register at the required rate or above.

3) The capability bit shall be set to a ONE (1) if at least one field in the Register is receiving valid data at the required rate with the status bits for all fields not receiving valid data at the required rate set to ZERO (0).

4) Registers 18_{16} to $1C_{16}$ shall be independent of Register 17_{16}.

5) Bit 6 is set to ONE (1) upon the first loading of Register $0A_{16}$ and shall remain set until either the transponder is powered OFF or ADS-B transmissions are terminated.

6) Bits 17 and 18 shall only be set to ONE (1) if the STATUS bit in Register 51_{16} is valid.

Table B-3-24: BDS Code 1,8 – MSSS GICB Capability Report (1 of 5)

MB FIELD

1	BDS 3,8
2	BDS 3,7
3	BDS 3,6
4	BDS 3,5
5	BDS 3,4
6	BDS 3,3
7	BDS 3,2
8	BDS 3,1
9	BDS 3,0
10	BDS 2,F
11	BDS 2,E
12	BDS 2,D
13	BDS 2,C
14	BDS 2,B
15	BDS 2,A
16	BDS 2,9
17	BDS 2,8
18	BDS 2,7
19	BDS 2,6
20	BDS 2,5
21	BDS 2,4
22	BDS 2,3
23	BDS 2,2
24	BDS 2,1
25	BDS 2,0
26	BDS 1,F
27	BDS 1,E
28	BDS 1,D
29	BDS 1,C
30	BDS 1,B
31	BDS 1,A
32	BDS 1,9
33	BDS 1,8
34	BDS 1,7
35	BDS 1,6
36	BDS 1,5
37	BDS 1,4
38	BDS 1,3
39	BDS 1,2
40	BDS 1,1
41	BDS 1,0
42	BDS 0,F
43	BDS 0,E
44	BDS 0,D
45	BDS 0,C
46	BDS 0,B
47	BDS 0,A
48	BDS 0,9
49	BDS 0,8
50	BDS 0,7
51	BDS 0,6
52	BDS 0,5
53	BDS 0,4
54	BDS 0,3
55	BDS 0,2
56	BDS 0,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to ONE (1).

Starting from the LSB, each bit position shall represent the Register number, in accordance with the following table:

BDS Code	**Capability installed for Register**
BDS 1,8	01_{16} to 38_{16}
BDS 1,9	39_{16} to 70_{16}
BDS 1,A	71_{16} to $A8_{16}$
BDS 1,B	$A9_{16}$ to $E0_{16}$
BDS 1,C	$E1_{16}$ to FF_{16}

The 25 most significant bits of Register $1C_{16}$ shall not be used.

Table B-3-25: BDS Code 1,9 – MSSS GICB Capability Report (2 of 5)

MB FIELD

1	BDS 7,0
2	BDS 6,F
3	BDS 6,E
4	BDS 6,D
5	BDS 6,C
6	BDS 6,B
7	BDS 6,A
8	BDS 6,9
9	BDS 6,8
10	BDS 6,7
11	BDS 6,6
12	BDS 6,5
13	BDS 6,4
14	BDS 6,3
15	BDS 6,2
16	BDS 6,1
17	BDS 6,0
18	BDS 5,F
19	BDS 5,E
20	BDS 5,D
21	BDS 5,C
22	BDS 5,B
23	BDS 5,A
24	BDS 5,9
25	BDS 5,8
26	BDS 5,7
27	BDS 5,6
28	BDS 5,5
29	BDS 5,4
30	BDS 5,3
31	BDS 5,2
32	BDS 5,1
33	BDS 5,0
34	BDS 4,F
35	BDS 4,E
36	BDS 4,D
37	BDS 4,C
38	BDS 4,B
39	BDS 4,A
40	BDS 4,9
41	BDS 4,8
42	BDS 4,7
43	BDS 4,6
44	BDS 4,5
45	BDS 4,4
46	BDS 4,3
47	BDS 4,2
48	BDS 4,1
49	BDS 4,0
50	BDS 3,F
51	BDS 3,E
52	BDS 3,D
53	BDS 3,C
54	BDS 3,B
55	BDS 3,A
56	BDS 3,9

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to ONE (1).

Table B-3-26: BDS Code 1,A – MSSS GICB Capability Report (3 of 5)

MB FIELD

1	BDS A,8
2	BDS A,7
3	BDS A,6
4	BDS A,5
5	BDS A,4
6	BDS A,3
7	BDS A,2
8	BDS A,1
9	BDS A,0
10	BDS 9,F
11	BDS 9,E
12	BDS 9,D
13	BDS 9,C
14	BDS 9,B
15	BDS 9,A
16	BDS 9,9
17	BDS 9,8
18	BDS 9,7
19	BDS 9,6
20	BDS 9.5
21	BDS 9,4
22	BDS 9,3
23	BDS 9,2
24	BDS 9,1
25	BDS 9,0
26	BDS 8,F
27	BDS 8,E
28	BDS 8,D
29	BDS 8,C
30	BDS 8,B
31	BDS 8,A
32	BDS 8,9
33	BDS 8,8
34	BDS 8,7
35	BDS 8,6
36	BDS 8,5
37	BDS 8,4
38	BDS 8,3
39	BDS 8,2
40	BDS 8,1
41	BDS 8,0
42	BDS 7,F
43	BDS 7,E
44	BDS 7,D
45	BDS 7,C
46	BDS 7,B
47	BDS 7,A
48	BDS 7,9
49	BDS 7,8
50	BDS 7,7
51	BDS 7,6
52	BDS 7,5
53	BDS 7,4
54	BDS 7,3
55	BDS 7,2
56	BDS 7,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to ONE (1).

Table B-3-27: BDS Code 1,B – MSSS GICB Capability Report (4 of 5)

MB FIELD

1	BDS E,0
2	BDS D,F
3	BDS D,E
4	BDS D,D
5	BDS D,C
6	BDS D,B
7	BDS D,A
8	BDS D,9
9	BDS D,8
10	BDS D,7
11	BDS D,6
12	BDS D,5
13	BDS D,4
14	BDS D,3
15	BDS D,2
16	BDS D,1
17	BDS D,0
18	BDS C,F
19	BDS C,E
20	BDS C,D
21	BDS C,C
22	BDS C,B
23	BDS C,A
24	BDS C,9
25	BDS C,8
26	BDS C,7
27	BDS C,6
28	BDS C,5
29	BDS C,4
30	BDS C,3
31	BDS C,2
32	BDS C,1
33	BDS C,0
34	BDS B,F
35	BDS B,E
36	BDS B,D
37	BDS B,C
38	BDS B,B
39	BDS B,A
40	BDS B,9
41	BDS B,8
42	BDS B,7
43	BDS B,6
44	BDS B,5
45	BDS B,4
46	BDS B.3
47	BDS B,2
48	BDS B,1
49	BDS B,0
50	BDS A,F
51	BDS A,E
52	BDS A,D
53	BDS A,C
54	BDS A,B
55	BDS A,A
56	BDS A,9

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to ONE (1).

Table B-3-28: BDS Code 1,C – MSSS GICB Capability Report (5 of 5)

MB FIELD

1	RESERVED
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	BDS F,F
27	BDS F,E
28	BDS F,D
29	BDS F,C
30	BDS F,B
31	BDS F,A
32	BDS F,9
33	BDS F,8
34	BDS F,7
35	BDS F,6
36	BDS F,5
37	BDS F,4
38	BDS F,3
39	BDS F,2
40	BDS F,1
41	BDS F,0
42	BDS E,F
43	BDS E,E
44	BDS E,D
45	BDS E,C
46	BDS E,B
47	BDS E,A
48	BDS E,9
49	BDS E,8
50	BDS E,7
51	BDS E,6
52	BDS E,5
53	BDS E,4
54	BDS E,3
55	BDS E,2
56	BDS E,1

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to ONE (1).

Table B-3-29: BDS Code 1,D – MSSS MSP Capability Report (1 of 3)

MB FIELD

1	Uplink MSP Channel 1
2	Uplink MSP Channel 2
3	Uplink MSP Channel 3
4	Uplink MSP Channel 4
5	Uplink MSP Channel 5
6	Uplink MSP Channel 6
7	Uplink MSP Channel 7
8	Uplink MSP Channel 8
9	Uplink MSP Channel 9
10	Uplink MSP Channel 10
11	Uplink MSP Channel 11
12	Uplink MSP Channel 12
13	Uplink MSP Channel 13
14	Uplink MSP Channel 14
15	Uplink MSP Channel 15
16	Uplink MSP Channel 16
17	Uplink MSP Channel 17
18	Uplink MSP Channel 18
19	Uplink MSP Channel 19
20	Uplink MSP Channel 20
21	Uplink MSP Channel 21
22	Uplink MSP Channel 22
23	Uplink MSP Channel 23
24	Uplink MSP Channel 24
25	Uplink MSP Channel 25
26	Uplink MSP Channel 26
27	Uplink MSP Channel 27
28	Uplink MSP Channel 28
29	Downlink MSP Channel 1
30	Downlink MSP Channel 2
31	Downlink MSP Channel 3
32	Downlink MSP Channel 4
33	Downlink MSP Channel 5
34	Downlink MSP Channel 6
35	Downlink MSP Channel 7
36	Downlink MSP Channel 8
37	Downlink MSP Channel 9
38	Downlink MSP Channel 10
39	Downlink MSP Channel 11
40	Downlink MSP Channel 12
41	Downlink MSP Channel 13
42	Downlink MSP Channel 14
43	Downlink MSP Channel 15
44	Downlink MSP Channel 16
45	Downlink MSP Channel 17
46	Downlink MSP Channel 18
47	Downlink MSP Channel 19
48	Downlink MSP Channel 20
49	Downlink MSP Channel 21
50	Downlink MSP Channel 22
51	Downlink MSP Channel 23
52	Downlink MSP Channel 24
53	Downlink MSP Channel 25
54	Downlink MSP Channel 26
55	Downlink MSP Channel 27
56	Downlink MSP Channel 28

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to ONE (1).

1) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service.

Table B-3-30: BDS Code 1,E – MSSS MSP Capability Report (2 of 3)

MB FIELD

1	Uplink MSP Channel 29
2	Uplink MSP Channel 30
3	Uplink MSP Channel 31
4	Uplink MSP Channel 32
5	Uplink MSP Channel 33
6	Uplink MSP Channel 34
7	Uplink MSP Channel 35
8	Uplink MSP Channel 36
9	Uplink MSP Channel 37
10	Uplink MSP Channel 38
11	Uplink MSP Channel 39
12	Uplink MSP Channel 40
13	Uplink MSP Channel 41
14	Uplink MSP Channel 42
15	Uplink MSP Channel 43
16	Uplink MSP Channel 44
17	Uplink MSP Channel 45
18	Uplink MSP Channel 46
19	Uplink MSP Channel 47
20	Uplink MSP Channel 48
21	Uplink MSP Channel 49
22	Uplink MSP Channel 50
23	Uplink MSP Channel 51
24	Uplink MSP Channel 52
25	Uplink MSP Channel 53
26	Uplink MSP Channel 54
27	Uplink MSP Channel 55
28	Uplink MSP Channel 56
29	Downlink MSP Channel 29
30	Downlink MSP Channel 30
31	Downlink MSP Channel 31
32	Downlink MSP Channel 32
33	Downlink MSP Channel 33
34	Downlink MSP Channel 34
35	Downlink MSP Channel 35
36	Downlink MSP Channel 36
37	Downlink MSP Channel 37
38	Downlink MSP Channel 38
39	Downlink MSP Channel 39
40	Downlink MSP Channel 40
41	Downlink MSP Channel 41
42	Downlink MSP Channel 42
43	Downlink MSP Channel 43
44	Downlink MSP Channel 44
45	Downlink MSP Channel 45
46	Downlink MSP Channel 46
47	Downlink MSP Channel 47
48	Downlink MSP Channel 48
49	Downlink MSP Channel 49
50	Downlink MSP Channel 50
51	Downlink MSP Channel 51
52	Downlink MSP Channel 52
53	Downlink MSP Channel 53
54	Downlink MSP Channel 54
55	Downlink MSP Channel 55
56	Downlink MSP Channel 56

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to ONE (1).

1) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service.

Table B-3-31: BDS Code 1,F – MSSS MSP Capability Report (3 of 3)

MB FIELD

1	Uplink MSP Channel 57
2	Uplink MSP Channel 58
3	Uplink MSP Channel 59
4	Uplink MSP Channel 60
5	Uplink MSP Channel 61
6	Uplink MSP Channel 62
7	Uplink MSP Channel 63
8–28	RESERVED
29	Downlink MSP Channel 57
30	Downlink MSP Channel 58
31	Downlink MSP Channel 59
32	Downlink MSP Channel 60
33	Downlink MSP Channel 61
34	Downlink MSP Channel 62
35	Downlink MSP Channel 63
36–56	RESERVED

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to ONE (1).

1) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service.

Table B-3-32: BDS Code 2,0 – Aircraft Identification (§2.2.19.1.13)

MB FIELD

1	MSB	
2		
3		
4		BDS Code 2,0
5		
6		
7		
8	LSB	
9	MSB	
10		
11		CHARACTER 1
12		
13		
14	LSB	
15	MSB	
16		
17		CHARACTER 2
18		
19		
20	LSB	
21	MSB	
22		
23		CHARACTER 3
24		
25		
26	LSB	
27	MSB	
28		
29		
30		CHARACTER 4
31		
32	LSB	
33	MSB	
34		
35		
36		CHARACTER 5
37		
38	LSB	
39	MSB	
40		
41		
42		CHARACTER 6
43		
44	LSB	
45	MSB	
46		
47		
48		CHARACTER 7
49		
50	LSB	
51	MSB	
52		
53		
54		CHARACTER 8
55		
56	LSB	

PURPOSE: To report aircraft identification to the ground.

1) See ICAO Annex 10, Volume IV, §3.1.2.9.

2) The character coding to be used shall be identical to that defined in Table B-2-2 of this Appendix.

3) This data may be input to the transponder from sources other than the Mode-S ADLP.

4) Characters 1 – 8 of this format shall be used by the Extended Squitter application.

5) Capability to support this Register shall be indicated by setting bit 33 in Register 10_{16} and the relevant bits in Registers 17_{16} and 18_{16}.

6) The aircraft identification shall be that employed in the flight plan. When no flight plan is available, the registration marking of the aircraft shall be used.

Note: *Additional implementation guidelines are provided in §B.4.3 of this Appendix.*

Table B-3-33: BDS Code 2,1 – Aircraft and Airline Registration Markings

MB FIELD

1	STATUS	
2	MSB	
3		
4	CHARACTER 1	
5		
6		
7	LSB	
8	MSB	
9		
10	CHARACTER 2	
11		
12		
13	LSB	
14	MSB	
15		
16	CHARACTER 3	
17		
18		
19	LSB	
20	MSB	
21		
22	CHARACTER 4	AIRCRAFT
23		REGISTRATION
24		NUMBER
25	LSB	
26	MSB	
27		
28	CHARACTER 5	
29		
30		
31	LSB	
32	MSB	
33		
34	CHARACTER 6	
35		
36		
37	LSB	
38	MSB	
39		
40	CHARACTER 7	
41		
42		
43	LSB	
44	STATUS	
45	MSB	
46		
47	CHARACTER 1	
48		
49		
50	LSB	ICAO AIRLINE
51	MSB	REGISTRATION
52		MARKING
53	CHARACTER 2	
54		
55		
56	LSB	

PURPOSE: To permit ground systems to identify the aircraft without the necessity of compiling and maintaining continuously updated data banks.

The character coding shall be as defined in Table B-2-2 of this Appendix.

Table B-3-34: BDS Code 2,2 – Antenna Positions

MB FIELD

1	MSB	
2	ANTENNA TYPE	
3	LSB	
4	MSB = 32 meters	
5		
6	X POSITION	
7	Range = [1, 63]	ANTENNA 1
8		
9	LSB = 1 meter	
10	MSB = 16 meters	
11		
12	Z POSITION	
13	Range = [1, 31]	
14	LSB = 1 meter	
15	MSB	
16	ANTENNA TYPE	
17	LSB	
18	MSB = 32 meters	
19		
20	X POSITION	
21	Range = [1, 63]	ANTENNA 2
22		
23	LSB = 1 meter	
24	MSB = 16 meters	
25		
26	Z POSITION	
27	Range = [1, 31]	
28	LSB = 1 meter	
29	MSB	
30	ANTENNA TYPE	
31	LSB	
32	MSB = 32 meters	
33		
34	X POSITION	
35	Range = [1, 63]	ANTENNA 3
36		
37	LSB = 1 meter	
38	MSB = 16 meters	
39		
40	Z POSITION	
41	Range = [1, 31]	
42	LSB = 1 meter	
43	MSB	
44	ANTENNA TYPE	
45	LSB	
46	MSB = 32 meters	
47		
48	X POSITION	
49	Range = [1, 63]	ANTENNA 4
50		
51	LSB = 1 meter	
52	MSB = 16 meters	
53		
54	Z POSITION	
55	Range = [1, 31]	
56	LSB = 1 meter	

PURPOSE: To provide information on the position of Mode-S and GNSS antennas on the aircraft in order to make very accurate Measurements of aircraft position possible.

1) The antenna type field shall be interpreted as follows:

   0 = Invalid
   1 = Mode-S bottom antenna
   2 = Mode-S top antenna
   3 = GNSS antenna
   4 to 7 = Reserved

2) The X position field shall be the distance in meters along the aircraft center line measured from the nose of the aircraft. The field shall be interpreted as invalid if the value is ZERO (0) and the value of 63 shall mean that the antenna position is 63 meters or more from the nose.

3) The Z position field shall be the distance in meters of the antenna from the ground, measured with the aircraft unloaded and on the ground. The field shall be interpreted as invalid if the value is ZERO (0), and the value of 31 shall mean that the antenna position is 31 meters or more from the ground.

Table B-3-37: BDS Code 2,5 – Aircraft Type

MB FIELD

1	MSB	
2		
3	AIRCRAFT TYPE	
4		
5		
6	LSB	
7	MSB	
8	NUMBER OF ENGINES	
9	LSB	
10	MSB	
11		
12	ENGINE TYPE	
13		
14		
15	LSB	
16	MSB	
17		
18	CHARACTER 1	
19		
20		
21	LSB	
22	MSB	
23		
24	CHARACTER 2	
25		
26		
27	LSB	
28	MSB	
29		
30	CHARACTER 3	MODEL
31		DESIGNATION
32		
33	LSB	
34	MSB	
35		
36	CHARACTER 4	
37		
38		
39	LSB	
40	MSB	
41		
42	CHARACTER 5	
43		
44		
45	LSB	
46	MSB	
47		
48	WAKE TURBULENCE	
49	CATEGORY	
50		
51	LSB	
52		
53		
54	RESERVED	
55		
56		

PURPOSE: To provide information on aircraft type.

1) Subfield coding

The coding shall be as in ICAO Doc 8643 – *Aircraft Type Designators*. All the subfields that contain characters shall be encoded using the 6-bit subset of IA-5 as specified in Table B-2-2 of this Appendix.

2) Model designation

Coding shall consist of four characters as specified in ICAO Doc 8643. The fifth character shall be reserved for future expansion and shall contain all ZEROs until it is specified. 2222 in the first four characters shall mean that the designator is not specified.

3) Number of engines

This subfield shall be encoded as a binary number where number 7 means 7 or more engines.

Table B-3-48: BDS Code 3,0 – TCAS/ACAS Active Resolution Advisory

MB FIELD

1	MSB
2	
3	
4	BDS Code 3,0
5	
6	
7	
8	LSB
9	MSB
10	
11	
12	
13	
14	
15	ACTIVE RESOLUTION ADVISORIES
16	
17	
18	
19	
20	
21	
22	LSB
23	MSB
24	RACs RECORD
25	
26	LSB
27	RA TERMINATED
28	MULTIPLE THREAT ENCOUNTER
29	MSB THREAT-TYPE INDICATOR
30	LSB
31	MSB
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	THREAT IDENTITY DATA
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To report resolution advisories (RAs) generated by TCAS/ACAS equipment.

The coding of this Register shall conform to:

1) See §2.2.22.1.2.1.

2) Bit 27 shall mean RA terminated when set to ONE (1).

Table B-3-64: BDS Code 4,0 – Selected Vertical Intention

MB FIELD

1	STATUS	
2	MSB = 32768 feet	
3		
4		
5	MCP/FCU SELECTED ALTITUDE	
6		
7	Range = [0, 65520] feet	
8		
9		
10		
11		
12		
13	LSB = 16 feet	
14	STATUS	
15	MSB = 32768 feet	
16		
17		
18	FMS SELECTED ALTITUDE	
19		
20	Range = [0, 65520] feet	
21		
22		
23		
24		
25		
26	LSB = 16 feet	
27	STATUS	
28	MSB = 204.8 mb	
29		
30		
31		
32	BAROMETRIC PRESSURE SETTING	
33	MINUS 800 mb	
34		
35	Range = [0, 410] mb	
36		
37		
38		
39	LSB = 0.1 mb	
40		
41		
42		
43		
44	RESERVED	
45		
46		
47		
48	STATUS OF MCP/FCU MODE BITS	
49	VNAV MODE	
50	ALT HOLD MODE	MCP/FCU Mode bits
51	APPROACH MODE	
52	RESERVED	
53		
54	STATUS OF TARGET ALT SOURCE BITS	
55	MSB TARGET ALT SOURCE	
56	LSB	

PURPOSE: To provide ready access to information about the aircraft's current vertical intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

1) Target altitude shall be the short-term intent value, at which the aircraft will level off (or has leveled off) at the end of the current maneuver. The data source that the aircraft is currently using to determine the target altitude shall be indicated in the altitude source bits (54 to 56) as detailed below.

   Note: *This information which represents the real "aircraft intent," when available, represented by the altitude control panel selected altitude, the flight management system selected altitude, or the current aircraft altitude according to the aircraft's mode of flight (the intent may not be available at all when the pilot is flying the aircraft).*

2) The data entered into bits 1 to 13 shall be derived from the mode control panel/flight control unit or equivalent equipment. Alerting devices may be used to provide data if it is not available from "control" equipment. The associated mode bits for this field (48 to 51) shall be as detailed below.

3) The data entered into bits 14 to 26 shall de derived from the flight management system or equivalent equipment managing the vertical profile of the aircraft.

4) The current barometric pressure setting shall be calculated from the value contained in the field (bits 28 to 39) plus 800 mb. When the barometric pressure setting is less than 800 mb or greater than 1209.5 mb, the status bit for this field (bit 27) shall be set to indicate invalid data.

5) Reserved bits 40 to 47 shall be set to ZERO (0).

6) Bits 48 to 56 shall indicate the status of the values provided in bits 1 to 26 as follows:

   Bit 48 shall indicate whether the mode bits (49, 50 and 51) are already being populated:
   - 0 = No mode information provided
   - 1 = Mode information deliberately provided

   Bits 49, 50 and 51:
   - 0 = Not active
   - 1 = Active

   Reserved bits 52 and 53 shall be set to ZERO (0).

   Bit 54 shall indicate whether the target altitude source bits (55 and 56) are actively being populated:
   - 0 = No source information provided
   - 1 = Source information deliberately provided

   Bits 55 and 56 shall indicate target altitude source:
   - 00 = Unknown
   - 01 = Aircraft altitude
   - 10 = FCU/MCP selected altitude
   - 11 = FMS selected altitude

Note: *Additional implementation guidelines are provided in §B.4.4 of this Appendix.*

Table B-3-65: BDS Code 4,1 – Next Waypoint Details

MB FIELD

1	STATUS
2	MSB
3	
4	CHARACTER 1
5	
6	
7	LSB
8	MSB
9	
10	CHARACTER 2
11	
12	
13	LSB
14	MSB
15	
16	CHARACTER 3
17	
18	
19	LSB
20	MSB
21	
22	CHARACTER 4
23	
24	
25	LSB
26	MSB
27	
28	CHARACTER 5
29	
30	
31	LSB
32	MSB
33	
34	CHARACTER 6
35	
36	
37	LSB
38	MSB
39	
40	CHARACTER 7
41	
42	
43	LSB
44	MSB
45	
46	CHARACTER 8
47	
48	
49	LSB
50	MSB
51	
52	CHARACTER 9
53	
54	
55	LSB
56	RESERVED

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

1) Each character shall be encoded as specified in Table B-2-2.

Table B-3-66: BDS Code 4,2 – Next Waypoint Details

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	
7	
8	
9	WAYPOINT LATITUDE
10	
11	Range = [-180, +180] degrees
12	
13	
14	
15	
16	
17	
18	
19	
20	LSB = 90/131072 degrees
21	STATUS
22	SIGN
23	MSB = 90 degrees
24	
25	
26	
27	
28	
29	
30	WAYPOINT LONGITUDE
31	
32	Range = [-180, +180] degrees
33	
34	
35	
36	
37	
38	
39	
40	LSB = 90/131072 degrees
41	STATUS
42	SIGN
43	MSB = 65536 feet
44	
45	
46	
47	WAYPOINT CROSSING
48	ALTITUDE
49	
50	Range = [-131072, +131064] feet
51	
52	
53	
54	
55	
56	LSB = 8 feet

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-67: BDS Code 4,3 – Next Waypoint Details

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	BEARING TO WAYPOINT
7	
8	Range = [-180, +180] degrees
9	
10	
11	
12	LSB = 360/2048 degrees
13	STATUS
14	MSB = 204.8 minutes
15	
16	
17	
18	TIME TO GO
19	
20	Range = [0, 410] minutes
21	
22	
23	
24	
25	LSB = 0.1 minutes
26	STATUS
27	MSB = 3276.8 NM
28	
29	
30	
31	
32	
33	DISTANCE TO GO
34	
35	Range = [0, 6554] NM
36	
37	
38	
39	
40	
41	
42	LSB = 0.1 NM
43	
44	
45	
46	
47	
48	
49	
50	RESERVED
51	
52	
53	
54	
55	
56	

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short and medium term tactical control.

1) The bearing to waypoint is the bearing from the current aircraft heading position to the waypoint position referenced to true north.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-72: BDS Code 4,8 – VHF Channel Report

MB FIELD

Bit		
1	MSB	
2		
3		
4		
5		
6		
7		
8		VHF 1
9		
10		
11		
12		
13		
14		
15	LSB	
16	STATUS	
17	MSB	VHF 1
18	LSB	AUDIO STATUS
19	MSB	
20		
21		
22		
23		
24		
25		
26		VHF 2
27		
28		
29		
30		
31		
32		
33	LSB	
34	STATUS	
35	MSB	VHF 2
36	LSB	AUDIO STATUS
37	MSB	
38		
39		
40		
41		
42		
43		VHF 3
44		
45		
46		
47		
48		
49		
50		
51	LSB	
52	STATUS	
53	MSB	VHF 3
54	LSB	AUDIO STATUS
55	MSB	121.5 MHz
56	LSB	AUDIO STATUS

PURPOSE: To allow the ATC system to monitor the settings of the VHF communications channel and to determine the manner in which each channel is being monitored by the aircrew.

Channel report coding:
Each VHF communications channel shall be determined form the 15-bit positive binary number, N in kHz, according to the formula:

Channel (MHz) = Base + N x 0.001 (MHz)

where: Base = 118.000 MHz

Notes:

1) *The use of binary to define the channel improves the coding efficiency.*
2) *This coding is compatible with analogue channels on 25 kHz, 8.33 kHz channel spacing and VDL as described below.*
3) *VDL has a full four bits allocated such that the active status of each of its four multiplex channels can be ascertained.*

25 kHz Bit	**VDL: Mode 3**	**Analogue**
16	Status	Status
15 (LSB)	MSB (12800 kHz)	MSB (12800 kHz)
	Range 118.000 to 143.575 136.975 (military use)	Range 118.000 to 143.575 136.975 (military use)
6	LSB (25 kHz)	LSB (25 kHz)
5	4 x channel active flags	Unused
4		Unused
3		Unused
2		8.33 indicator = 0
1 (MSB)	VDL indicator = 1	VDL indicator = 0

8.33 kHz Bit	**Analogue**
16	Status
15 (LSB)	MSB (17066 kHz)
...	Range 118.000 to 152.112 136.975 (military use)
4	LSB (17066/2048 kHz)
3	Unused
2	8.33 indicator = 1
1 (MSB)	VDL indicator = 0

Audio status coding:
Each pair of audio status bits shall be used to describe the aircrew monitoring of that audio channel according to the following table:

Bit 1 (MSB)	**Bit 2 (LSB)**	
0	0	UNKNOWN
0	1	NOBODY
1	0	HEADPHONES ONLY
1	1	LOUDSPEAKER

Table B-3-80: BDS Code 5,0 – Track and Turn Report

MB FIELD

1	STATUS
2	SIGN 1 = Left Wing Down
3	MSB = 45 degrees
4	
5	
6	ROLL ANGLE
7	
8	Range = [-90, + 90] degrees
9	
10	
11	LSB = 45/256 degrees
12	STATUS
13	SIGN 1 = West (e.g., 315 = -45 degrees)
14	MSB = 90 degrees
15	
16	
17	TRUE TRACK ANGLE
18	
19	Range = [-180, +180] degrees
20	
21	
22	
23	LSB = 90/512 degrees
24	STATUS
25	MSB = 1024 knots
26	
27	
28	GROUND SPEED
29	
30	Range = [0, 2046] knots
31	
32	
33	
34	LSB = 1024/512 knots
35	STATUS
36	SIGN 1 = Minus
37	MSB = 8 degrees/second
38	
39	
40	TRACK ANGLE RATE
41	Range = [-16, +16] degrees/second
42	
43	
44	
45	LSB = 8/256 degrees/second
46	STATUS
47	MSB = 1024 knots
48	
49	
50	TRUE AIRSPEED
51	
52	Range = [0, 2046] knots
53	
54	
55	
56	LSB = 2 knots

PURPOSE: To provide track and turn data to the ground systems.

1) If the value of the parameter from any source exceeds the range allowable in the Register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

   Note 1: *This requires active intervention by the GFM.*

2) The data entered into the Register shall, whenever possible, be derived from the sources that are controlling the aircraft.

3) If any parameter is not available on the aircraft, all bits corresponding to that parameter shall be actively set to ZERO (0) by the GFM.

4) The LSB of all fields shall be obtained by rounding.

Note 2: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Note 3: *Additional implementation guidelines are provided in §B.4.5 of this Appendix.*

Table B-3-81: BDS Code 5,1 – Position Report Coarse

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	
7	
8	
9	LATITUDE
10	
11	Range = [-180, +180] degrees
12	(see 2)
13	
14	
15	
16	
17	
18	
19	
20	
21	LSB = 360/1048576 degrees
22	SIGN
23	MSB = 90 degrees
24	
25	
26	
27	
28	LONGITUDE
29	
30	Range = [-180, +180] degrees
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	LSB = 360/1048576 degrees
42	SIGN
43	MSB = 65536 feet
44	
45	
46	
47	PRESSURE
48	ALTITUDE
49	
50	Range = [-1000, +126752] feet
51	
52	
53	
54	
55	
56	LSB = 8 feet

PURPOSE: To provide a three-dimensional report of aircraft position.

1) The single status bit (bit 1) shall only be set to ONE (1) if at least latitude and longitude in Register 51_{16} and FOM in Register 52_{16} are valid. This bit shall be identical to the status bit in Register 52_{16}.

2) The required valid range for latitude is +90 degrees to -90 degrees, but the parameter shall be coded with an MSB of 90 degrees to allow the use of the same coding algorithm as for longitude.

3) The source of the information in this Register shall be the same as that indicated in the FOM/SOURCE field of Register 52_{16}.

4) If the barometric pressure is invalid then the field shall be set to ALL ZEROs, but the status bit (#1) shall not be affected.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-82: BDS Code 5,2 – Position Report Fine

MB FIELD

1	STATUS (see 1)
2	MSB
3	FOM/SOURCE
4	
5	LSB
6	MSB = 90/128 degrees
7	
8	
9	
10	
11	
12	
13	LATITUDE FINE
14	
15	Range = [0, 180/128] degrees
16	
17	
18	
19	
20	
21	
22	
23	LSB = 90/16777216 degrees
24	MSB = 90/128 degrees
25	
26	
27	
28	
29	
30	
31	LONGITUDE FINE
32	
33	Range = [0, 180/128] degrees
34	
35	
36	
37	
38	
39	
40	
41	LSB = 90/16777216 degrees
42	SIGN
43	MSB = 65536 feet
44	
45	
46	
47	PRESSURE ALTITUDE
48	OR
49	GNSS HEIGHT (HAE)
50	
51	Range = [-1000, +126752] feet
52	
53	
54	
55	
56	LSB = 8 feet

PURPOSE: To provide a high-precision three-dimensional report on aircraft position when used in conjunction with Register 51_{16}. information on the source of the data is included.

FOM/SOURCE Coding:
The decimal value of the binary-coded (Figure of Merit) FOM / SOURCE parameter shall be interpreted as follows:

0 = FOM > 10 NM or Unknown Accuracy
1 = FOM 10 NM/18.5 km (e.g., INS data) pressure altitude
2 = FOM 4 NM/7.4 km (e.g., VOR/DME) pressure altitude
3 = FOM 2 NM/3.7 km (e.g., DME/DME or GNSS) pressure altitude
4 = FOM 1 NM/1.85 km (e.g., DME/DME or GNSS) pressure altitude
5 = FOM 0.5 NM/926 m (e.g., DME/DME or GNSS) pressure altitude
6 = FOM 0.3 NM/556 m (e.g., DME/DME or GNSS) pressure altitude
7 = FOM 0.1 NM/185.2 m (ILS, MLS or differential GNSS) pressure altitude
8 = FOM 0.05 NM/92.6 m (ILS, MLS or differential GNSS) pressure altitude
9 = FOM 30 m (ILS, MLS or differential GNSS) pressure altitude
10 = FOM 10 m (ILS, MLS or differential GNSS) pressure altitude
11 = FOM 3 m (ILS, MLS or differential GNSS) pressure altitude
12 = FOM 30 m (ILS, MLS or differential GNSS) GNSS height
13 = FOM 10 m (ILS, MLS or differential GNSS) GNSS height
14 = FOM 3 m (ILS, MLS or differential GNSS) GNSS height
15 = Reserved

Note 1: *When GNSS is the source, then the FOM is encoded by the HFOM parameter. When RNP FMS is the source, the FOM is encoded by the ANP.*

1) The single status bit (bit 1) shall be set to ONE (1) if at least latitude and longitude in Register 51_{16} and FOM in Register 52_{16} are valid. This bit shall be identical to the status bit in Register 51_{16}.

2) The LATITUDE (fine) and LONGITUDE (fine) parameters are in 2's complement coding so they shall be interpreted in conjunction with the corresponding parameters in Register 51_{16}.

3) When GNSS height is contained in bits 42 to 56, the pressure altitude can be obtained from Register 51_{16}.

4) If the Pressure Altitude and the GNSS Height are invalid, then the field shall be set to ALL ZEROs, but the status bit (#1) shall not be affected.

Note 2: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Note 3: *The Figure of Merit selected is the smallest number that encompasses the HFOM or the ANP.*

Note 4: *When LATITUDE (fine) and LONGITUDE (fine) are not available, the setting of the single Status bit is not impacted and LATITUDE (fine) and LONGITUDE (fine) are zeroed.*

Table B-3-83: BDS Code 5,3 – Air-Referenced State Vector

MB FIELD

Bit	Field
1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	
6	MAGNETIC HEADING
7	
8	Range = [-180, +180] degrees
9	
10	
11	
12	LSB = 90/512 degrees
13	STATUS
14	MSB = 512 knot
15	
16	
17	INDICATED AIRSPEED (IAS)
18	
19	Range = [0, 1023] knots
20	
21	
22	
23	LSB = 1 knot
24	STATUS
25	MSB = MACH 2.048
26	
27	
28	MACH NUMBER
29	
30	Range = [0, 4.096] MACH
31	
32	
33	LSB = MACH 0.008
34	STATUS
35	MSB = 1024 knots
36	
37	
38	
39	
40	TRUE AIRSPEED
41	
42	Range = [0, 2048] knots
43	
44	
45	
46	LSB = 0.5 knots
47	STATUS
48	SIGN
49	MSB = 8192 feet/minute
50	
51	ALTITUDE RATE
52	
53	Range = [-16384, +16320] feet/minute
54	
55	
56	LSB = 64 feet/minute

PURPOSE: To provide the ATC system with current measured values of magnetic heading. IAS/MACH, altitude rate and TAS.

Note: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

Table B-3-84 to B-3-86: BDS Codes 5,4 to 5,6 – Waypoints 1, 2 and 3

MB FIELD

1	STATUS (see 1)
2	MSB
3	
4	CHARACTER 1
5	
6	
7	LSB
8	MSB
9	
10	CHARACTER 2
11	
12	
13	LSB
14	MSB
15	
16	CHARACTER 3
17	
18	
19	LSB
20	MSB
21	
22	CHARACTER 4
23	
24	
25	LSB
26	MSB
27	
28	CHARACTER 5
29	
30	
31	LSB
32	MSB = 30 minutes
33	
34	ESTIMATED TIME OF ARRIVAL
35	(NORMAL FLIGHT)
36	
37	Range = [0, 60] minutes
38	
39	
40	LSB = 60/512 minutes
41	MSB = 320 FL
42	
43	ESTIMATED FLIGHT LEVEL
44	(NORMAL FLIGHT)
45	Range = [0, 630] FL
46	LSB = 10 FL
47	MSB = 30 minutes
48	
49	TIME TO GO
50	(DIRECT ROUTE)
51	
52	Range = [0, 60] minutes
53	
54	
55	LSB = 60/512 minutes
56	RESERVED

PURPOSE: To provide information on the next three waypoints, where Register 54_{16} contains information on the next waypoint, Register 55_{16} contains information on the next waypoint plus one, and Register 56_{16} contains information on the next waypoint plus two.

1) The single status bit shall be set to ZERO (0) if any of the parameters are invalid.

2) The actual time or flight level shall be calculated from the trajectory scheduled in the FMS.

   Note: *Mode detail on the next waypoint is given in Register 41_{16} to 43_{16}.*

3) When the waypoint identity has only three characters, two leading ZERO (0) characters shall be added (e.g., CDN becomes 00CDN).

4) Estimated time is in minutes, and ALL ONEs shall be used to indicate that the waypoint referred to is one hour or more away.

Table B-3-95: BDS Code 5,F – Quasi-Static Parameter Monitoring

MB FIELD

1	MSB	MCP/FCU SELECTED ALTITUDE
2	LSB	
3		RESERVED
4		
5		RESERVED
6		
7		RESERVED
8		
9		RESERVED
10		
11		RESERVED
12		
13	MSB	NEXT WAYPOINT
14	LSB	
15		RESERVED
16		
17	MSB	FMS VERTICAL MODE
18	LSB	
19	MSB	VHF CHANNEL REPORT
20	LSB	
21	MSB	METEOROLOGICAL HAZARDS
22	LSB	
23	MSB	FMS SELECTED ALTITUDE
24	LSB	
25	MSB	BAROMETRIC PRESSURE
26	LSB	SETTING MINUS 800 mb
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		RESERVED
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		

PURPOSE: To permit the monitoring of changes in parameters that do not normally change very frequently, i.e., those expected to be stable for 5 minutes or more by accessing a single Register.

Parameter Monitor Coding:

1) The changing of each parameter shall be monitored by 2 bits. The value 00 shall indicate that no valid data are available on this parameter. The decimal value for this 2-bit field shall be cycled through 1, 2 and 3, each step indicating a change in the monitored parameter.

2) The meteorological hazards subfield shall report changes to turbulence, wind shear, wake vortex, icing and microburst, as in Register number 45_{16}.

3) The next waypoint subfield shall report change to data contained in Registers 41_{16}, 42_{16} and 43_{16}.

4) The FMS vertical mode shall report change to bits 48 to 51 in Register 40_{16}.

Table B-3-96: BDS Code 6,0 – Heading and Speed Report

MB FIELD

1	STATUS
2	SIGN 1=West (e.g., 315 = -45 degrees)
3	MSB = 90 degrees
4	
5	
6	MAGNETIC HEADING
7	
8	Range = [-180, +180] degrees
9	
10	
11	
12	LSB = 90/512 degrees
13	STATUS
14	MSB = 512 knots
15	
16	
17	INDICATED AIRSPEED
18	
19	Range = [0, 1023] knots
20	
21	
22	
23	LSB = 1 knot
24	STATUS
25	MSB = 2.048 MACH
26	
27	
28	MACH
29	
30	Range = [0, 4.092] MACH
31	
32	
33	
34	LSB = 2.048/512 MACH
35	STATUS
36	SIGN 1=Below
37	MSB = 8192 feet/minute
38	
39	
40	BAROMETRIC ALTITUDE RATE
41	
42	Range = [-16384, +16352] feet/minute
43	
44	
45	LSB = 8192/256 = 32 feet/minute
46	STATUS
47	SIGN 1=Below
48	MSB = 8192 feet/minute
49	
50	
51	INERTIAL VERTICAL VELOCITY
52	
53	Range = [-16384, +16352] feet/minute
54	
55	
56	LSB = 8192/256 = 32 feet/minute

PURPOSE: To provide heading and speed data to ground systems.

1) If the value of a parameter from any source exceeds the range allowable in the Register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

   Note 1: *This requires active intervention by the GFM.*

2) The data entered into the Register shall whenever possible be derived from the sources that are controlling the aircraft.

3) The LSB of all fields shall be obtained by rounding.

4) When barometric altitude rate is integrated and smoothed with inertial vertical velocity (baro-inertial information) it shall be transmitted in the Inertial Vertical Velocity field.

   Note 2: *Barometric Altitude Rate contains values solely derived from barometric measurement. The Barometric Altitude Rate is usually very unsteady and may suffer from barometric instrument inertia.*

   Note 3: *The Inertial Vertical Velocity is also providing information on vertical movement of the aircraft but it comes from equipments (IRS, AHRS) using different sources used for navigation. The information is a more filtered and smooth parameter.*

   Note 4: *Two's complement coding is used for all signed fields as specified in §B.2.2.2 of this Appendix.*

   Note 5: *Additional implementation guidelines are provided in §B.4.6 of this Appendix.*

Table B-3-227: BDS Code E,3 – Transponder Type / Part Number

MB FIELD

Bit	Part number (P/N) coding	Character coding
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide Mode-S transponder part number or type as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If the part number is not available, the first 8 characters of the commercial name can be used with the format type "01."

3) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table B-2-2. Character 1 is the first left character of the transponder type.

4) For operational reasons, some military installations may not implement this format.

Table B-3-228: BDS Code E,4 – Transponder Software Revision Number

MB FIELD

Bit	P/N coding	Character coding
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide Mode-S transponder software revision number as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When a part number is allocated to the software revision, it is recommended to use the format type "00." In this case, P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table B-2-2. Character 1 is the first left character of the software revision number.

3) For operational reasons, some military installations may not implement this format.

Table B-3-229: BDS Code E,5 – TCAS/ACAS Unit Part Number

MB FIELD

Bit	P/N coding	Character coding
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide TCAS/ACAS unit part number or type as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If the part number is not available, the first 8 characters of the commercial name can be used with the format type “01.”

3) If format type “01” is used, the coding of character 1 to 8 shall be as defined in Table B-2-2. Character 1 is the first left character of the TCAS/ACAS unit type.

4) For operational reasons, some military installations may not implement this format.

Table B-3-230: BDS Code E,6 – TCAS/ACAS Unit Software Revision

MB FIELD

Bit		
1	STATUS	
2	MSB FORMAT TYPE	
3	LSB	
4	MSB	MSB
5	P/N	
6	Digit 1	CHARACTER 1
7	LSB	
8	MSB	
9	P/N	LSB
10	Digit 2	MSB
11	LSB	
12	MSB	CHARACTER 2
13	P/N	
14	Digit 3	
15	LSB	LSB
16	MSB	MSB
17	P/N	
18	Digit 4	CHARACTER 3
19	LSB	
20	MSB	
21	P/N	LSB
22	Digit 5	MSB
23	LSB	
24	MSB	CHARACTER 4
25	P/N	
26	Digit 6	
27	LSB	LSB
28	MSB	MSB
29	P/N	
30	Digit 7	CHARACTER 5
31	LSB	
32	MSB	
33	P/N	LSB
34	Digit 8	MSB
35	LSB	
36	MSB	CHARACTER 6
37	P/N	
38	Digit 9	
39	LSB	LSB
40	MSB	MSB
41	P/N	
42	Digit 10	CHARACTER 7
43	LSB	
44	MSB	
45	P/N	LSB
46	Digit 11	MSB
47	LSB	
48	MSB	CHARACTER 8
49	P/N	
50	Digit 12	
51	LSB	LSB
52		
53		
54	RESERVED	RESERVED
55		
56		

PURPOSE: To provide TCAS/ACAS unit software revision number as defined by the supplier.

FORMAT TYPE CODING:

Bit 2	Bit 3	
0	0	= Part number (P/N) coding
0	1	= Character coding
1	0	= Reserved
1	1	= Reserved

1) When available it is recommended to use the part number. P/N Digits are BCD encoded. Digit 1 is the first left digit of the part number.

2) If format type "01" is used, the coding of character 1 to 8 shall be as defined in Table B-2-2. Character 1 is the first left character of the TCAS/ACAS unit software revision.

3) For operational reasons, some military installations may not implement this format.

Table B-3-231: BDS Code E,7 – Transponder Status and Diagnostics

MB FIELD

1	MSB
2	
3	
4	BDS Register Number = E,7
5	
6	
7	
8	LSB
9	MSB “SDI” Code
10	LSB
11	Non-Diversity Transponder
12	Diversity Failure
13	Upper Receiver Failure
14	Lower Receiver Failure
15	Upper Squitter Failure
16	Lower Squitter Failure
17	Air/Ground #1 Input Status
18	Air/Ground #2 Input Status
19	GPS Time Mark #1 Status
20	GPS Time Mark #2 Status
21	Mode S Limiting During Power-ON Cycle
22	Mode S Limiting
23	Extended Squitter Disable Status
24	TCAS Input Inactive
25	ADS-B Out Status
26	Selected Control Inactive or Failure
27	MSB Control Input Selection
28	LSB
29	MSB Multiple Air Data Source Reporting
30	LSB Selection (e.g., Source in Use)
31	Altitude Alternate Port Selection
32	MSB Altitude Port A Status
33	LSB
34	MSB Altitude Port B Status
35	LSB
36	FMC/GNSS Source Select
37	MSB FMC/GNSS #1 Bus Status
38	LSB
39	MSB FMC/GNSS #2 Bus Status
40	LSB
41	MSB Multiple IRS/AHRS Data Source
42	LSB Reporting Selection (e.g., source in Use)
43	IRS/FMS Source Select
44	MSB IRS/FMS/Data Concentrator In #1
45	LSB
46	MSB IRS/FMS/Data Concentrator In #2
47	LSB
48	FMC Select
49	MSB FMC #1/Gen. In Bus Status
50	LSB
51	MSB FMC #2/Gen. In Bus Status
52	LSB
53	MSB MSP/ATSU/CMU In #1 Status
54	LSB
55	MSB MSP/ATSU/CMU In #2 Status
56	LSB

PURPOSE: To report the configuration and status of the Transponder at any given GICB request.

The coding of this Register shall conform to:
Bits 9 & 10 for the SDI Code **shall** be coded as follows:
“00” = Not Used “01” = Side 1
“10” = Side 2 “11” = Not Used

Bit 11 for Non-Diversity Transponder **shall** be coded as follows:
“0” = Diversity
“1” = Non-Diversity

Bits 12 through 16, and 24 through 26 **shall** be coded as follows:
“0” = Ok
“1” = Failure

Bits 17 through 20, and Bit 23 **shall** be coded as follows:
“0” = Inactive or Unknown
“1” = Active

Mode S Limiting During Power-ON Cycle **shall** be coded as follows:
“0” = No Limiting Event
“1” = Limiting Event

Bit 22 for Mode S Limiting **shall** be coded as follows:
“0” = Ok
“1” = Active (e.g. In Limiting)

Bits 24 through 26 **shall** be coded as follows:
“0” = Active
“1” = Inactive or Failed

Bits 27 & 28 for Control Input Selection **shall** be coded as follows:
“00” = Burst Tune “01” = Port A or 1
“10” = Port B or 2 “11” = Port C or 3

Bits 29 through 30 and 41 through 42 **shall** be coded as follows:
“00” = No Data or Not Used “01” = Source #1 is being Used
“10” = Source #2 is being used “11” = Source # 3 is being Used

Altitude Alternate Port Selection **shall** be coded as follows:
“0” = Port A Selected
“1” = Alternate Port Selection is Active, e.g., Port B selected

Bits 32 through 35, 37 through 40, 44 through 47, and 49 through 56 **shall** be coded as follows:
“00” = No Data or Not Used “01” = Active
“10” = Inactive “11” = Fail

Bits 36, 43, and 48 **shall** be coded as follows:
“0” = Port #1 Selected
“1” = Port #2 Selected

Table B-2-234: BDS Code E,A – Vendor Specific Status and Diagnostics

MB FIELD

1	MSB
2	
3	
4	
5	BDS Register Number = E,A
6	
7	
8	LSB
9	
10	Manufacturer defined diagnostic field
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
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53	
54	
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56	

PURPOSE: To report diagnostic status and configuration information in a format defined by the transponder manufacturer.

1) This Register allows manufacturers to define configuration and status data that may be specific to their implementation or installation. This Register is designed to be a compliment to Register $E7_{16}$.

2) This Register should only be serviced if the transponder hardware and software can be identified via service of Register $E3_{16}$ and/or Register $E4_{16}$.

Table B-3-241: BDS Code F,1 – Military Applications

MB FIELD

1	STATUS	
2	Character Field (see 1)	
3	C1	
4	A1	
5	C2	
6	A2	
7	C4	
8	A4	MODE 1 CODE
9	X	
10	B1	
11	D1	
12	B2	
13	D2	
14	B4	
15	D4	
16	STATUS	
17	C1	
18	A1	
19	C2	
20	A2	
21	C4	
22	A4	MODE 2 CODE
23	X	
24	B1	
25	D1	
26	B2	
27	D2	
28	B4	
29	D4	
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		RESERVED
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		

PURPOSE: To provide data in support of military applications.

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

   0 = 2 octal codes
   (A1 – A4 and B1 – B4)

   1 = 4 octal codes
   (A1 – A4, B1 – B4, C1 – C4 and D1 – D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

   0 = Unavailable
   1 = Available

Table B-3-242: BDS Code F,2 – Military Applications

MB FIELD

1	MSB	
2		
3	AF=2, TYPE CODE = 1	
4		
5	LSB	
6	STATUS	
7	CHARACTER FIELD (see 1)	
8	C1	
9	A1	
10	C2	
11	A2	
12	C4	
13	A4	
14	X	MODE 1 CODE
15	B1	
16	D1	
17	B2	
18	D2	
19	B4	
20	D4	
21	STATUS	
22	C1	
23	A1	
24	C2	
25	A2	
26	C4	
27	A4	
28	X	MODE 2 CODE
29	B1	
30	D1	
31	B2	
32	D2	
33	B4	
34	D4	
35	STATUS	
36	C1	
37	A1	
38	C2	
39	A2	
40	C4	
41	A4	
42	X	MODE A CODE
43	B1	
44	D1	
45	B2	
46	D2	
47	B4	
48	D4	
49		
50		
51		
52		RESERVED
53		
54		
55		
56		

PURPOSE: This Register is used for military applications involving DF=19. Its purpose is to provide data in support of military applications.

'TYPE CODE' shall be encoded as follows:

0 = Unassigned
1 = Mode code information
2-31 = Unassigned

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

0 = 2 octal codes
(A1 – A4 and B1 – B4)

1 = 4 octal codes
(A1 – A4, B1 – B4, C1 – C4 and D1 – D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

0 = Unavailable
1 = Available

DF = 19 Application Field (AF) shall be encoded as follows:

0 = Reserved for civil Extended Squitter formats
1 = Reserved for formation flight
2 = Reserved for military applications
3-7 = Reserved

B.4 Implementation Guidelines

This section provides implementation guidelines on data formats for applications using Mode S Specific Services contained in this Appendix. The section is intended for use by the avionics industry and by the developers of air traffic services (ATS) applications.

B.4.1 Transponder Register 10_{16} (ICAO Doc 9871, Edition 2, §D.2.4.1)

The following sections state the guidance material that apply for the setting of some specific bits of transponder Register 10_{16}.

B.4.1.1 Bit 9 (Continuation Flag)

This bit should be set as specified in Table B-3-16.

In order to determine the extent of any continuation of the data link capability report (into those Registers reserved for this purpose: Register 11_{16} to Register 16_{16}), bit 9 is reserved as a 'continuation flag' to indicate if the subsequent Register can be extracted. For example: upon detection of bit 9=1 in Register 10_{16} then Register 11_{16} can be extracted. If bit 9=1 in Register 11_{16} then Register 12_{16} can be extracted, and so on (up to Register 16_{16}). Note that if bit 9=1 in Register 16_{16} then this shall be considered as an error condition.

As long as transponder Registers 11_{16} to 16_{16} are undefined, bit 9 should be set to ZERO (0).

B.4.1.2 Bit 16 and Bits 37 – 40 (TCAS Bits)

The setting of these bits is dynamic. They are set by TCAS and possibly overwritten by the transponder.

These bits should be set as specified in Table B-3-16.

Bit 16 should be set to ONE (1) to indicate that the transponder TCAS interface is operational and the transponder is receiving TCAS RI=2, 3 or 4.

Bit 37 should be set to ONE (1) to indicate the capability of Hybrid Surveillance, and set to ZERO (0) to indicate that there is no Hybrid Surveillance capability.

Bit 38 should be set to ONE (1) to indicate that the TCAS is generating both TAs and RAs, and set to ZERO (0) to indicate the generation of TAs only.

Bits 39 and 40 should be set according to the TCAS version:

Bit 40	Bit 39	Meaning
0	0	DO-185 (6.04A)
0	1	DO-185A
1	0	DO-185B
1	1	Reserved for future versions

Note: *Future versions of TCAS will be identified using Part Numbers and Software Version Numbers specified in Registers $E5_{16}$ and $E6_{16}$.*

B.4.1.3 Bits 17 – 23 (Mode S Subnetwork Version Number)

These bits should be set as specified in Table B-3-16.

Bits 17 – 23 reflect the Mode S Subnetwork Version Number.

Version Number	ICAO	RTCA	EUROCAE
0	Mode S Subnetwork Not Available		
1	ICAO Doc 9688 (1996)		
2	ICAO Doc 9688 (1998)		
3	ICAO Annex 10, Vol III, Amendment 77		
4	ICAO Doc 9871, Edition 1	DO-181D	ED-73C
5	ICAO Doc 9871, Edition 2	DO-181E	ED-73E
6–127	Reserved		

The Mode S Subnetwork Version Number should be set to a non-zero value if at least one DTE or Mode S Specific Service is installed. For example, if Register 40_{16} is loaded with data, it means that the GICB service associated to Register 40_{16} is installed. In that case bits 17-23 will be set to a non zero value, e.g., value 3 if the format of Register 40_{16} meets the requirements of Amendment 77 (applicable in 2002).

If the installed DTE or the Mode S Specific Services meet the requirements of Amendment 71 (applicable in 1996) only, then the Mode S Subnetwork Version Number should be set to ONE (1).

If the installed DTE or the Mode S Specific Services meet the requirements of Amendment 73 (applicable in 1998) only and/or the transponder Register formats meet the requirements of ICAO Doc 9688 version 1, then the Mode S Subnetwork Version Number should be set to TWO (2).

If the installed DTE or the Mode S Specific Services meet the requirements of Amendment 77, then the Mode S Subnetwork Version Number should be set to THREE (3).

The Mode S subnetwork number is set to 5 by a transponder implementing any Mode S Specific Services as defined in this edition of RTCA DO-181E / EUROCAE ED-73E.

The setting of these bits is static.

B.4.1.4 Bit 24 (Transponder Enhanced Protocol Indicator)

This bit is set to ONE (1) when the transponder is a Level 5 Transponder. This bit is set by the Transponder itself. It is a static bit.

B.4.1.5 Bit 25 (Mode S Specific Services Capability)

This bit should be set as specified in Table B-3-16, item 2.

When Bit 25 is set to ONE (1), it indicates that at least one Mode S specific service is supported and the particular capability reports should be checked.

Note: *Registers accessed by BDS Codes 0,2; 0,3; 0,4; 1,0; 1,7 through 1,C; 2,0 and 3,0 do not affect the setting of Bit 25.*

This bit actually indicates if the aircraft installation enables the loading of airborne parameters in at least one register not accessed by the BDS Codes mentioned above.

The setting of this bit is preferably static.

B.4.1.6 Bits 26 – 32 (Uplink and Downlink ELM Throughput Capability)

Bits 26 – 28 indicate the uplink ELM average throughput capability. These bits are set by the transponder and are preferably static.

Bits 29 – 32 indicate the throughput capability of downlink ELM containing the maximum number of ELM segments that the transponder can deliver in response to an interrogation. These bits are set by the transponder and are preferably static.

B.4.1.7 Bit 33 (Aircraft Identification Capability)

This bit should be set as required in ICAO Annex 10, Volume IV, §3.1.2.9.1.3.

Aircraft identification capability report. Transponders which respond to a ground-initiated request for aircraft identification shall report this capability in the data link capability report (ICAO Annex 10, Volume IV, §3.1.2.6.10.2.2.) by setting Bit 33 of the MB subfield to ONE (1).

This bit actually indicates whether the aircraft installation supports an interface to load the aircraft identification into the transponder Register 20_{16}. It does not take into account the consistency of the data loaded into the Register.

The setting of this bit is preferably dynamic. In case it is statically handled it should be forced to ONE (1).

When this bit is dynamic, it is always equal to Bit 7 of Register 17_{16}. It might be different from Bit 25 of Register 18_{16} since the bits of Registers 18_{16} to $1C_{16}$ are not reset once they are set. If the interface availability changes during the flight Bit 33 of Register 10_{16} and Bit 7 of Register 17_{16} will be updated accordingly whereas Bit 25 of Register 18_{16} will remain unchanged.

Note 1: *The intent of the capability bits in Register 17_{16} is to indicate that useful data are contained in the corresponding transponder Register. For this reason, each bit for a Register is cleared if data becomes unavailable (see ICAO Doc 9871, §A.2.5.4.1) and set again when data insertion into the Register resumes.*

Note 2: *A bit set in Registers 18_{16} to $1C_{16}$ indicates that the application using this Register has been installed on the aircraft. These bits are not cleared to reflect the real-time loss of an application, as is done for Register 17_{16} (see ICAO Doc 9871, §A.2.5.4.2).*

It is also to be noted that Register 10_{16} will be broadcasted twice following the interface availability change. The first time because Bit 33 will change, then because Bit 36 will also toggle approximately one minute later to indicate that the content of Register 17_{16} has changed.

B.4.1.8 Bit 34 (Squitter Capability Subfield)

This bit should be set as specified in Table B-3-16.

The Squitter Capability Subfield (SCS) is interpreted as follows:

0 = squitter registers are not updated
1 = squitter registers are being updated

In addition, ICAO Annex 10, Volume IV states in §3.1.2.6.10.2.2.1:

SCS: This 1-bit Squitter Capability Subfield reports the capability of the transponder to transmit Extended Squitter position reports. It shall be set to ONE (1) if Registers 05_{16} and 06_{16} have been updated within the last ten ±1 seconds. Otherwise, it shall be set to ZERO (0).

Bit 34 is therefore an AND of Bits 1 and 2 of transponder Register 17_{16} and the setting of this bit is dynamic.

Note that Register 10_{16} will be broadcast twice in case Bit 34 changes. The first time because Bit 34 will change, then because Bit 36 will also toggle one minute later to indicate that the content of Register 17_{16} has changed.

B.4.1.9 Bit 35 (SI Code capability)

This bit should be set as specified in Table B-3-16, item 6.

The Surveillance Identifier (SI) bit is interpreted as follows:

0 = no surveillance identifier code capability
1 = surveillance identifier code capability

In addition, ICAO Annex 10, Volume IV states in §3.1.2.6.10.2.2.1:

SIC: This 1-bit surveillance identifier capability subfield reports the capability of the transponder to support the Surveillance Identifier (SI) codes.

The setting of this bit is static. If the transponder software version handles SI codes then this bit should be set to (1).

B.4.1.10 Bit 36 (Common Usage GICB Capability Report)

This bit should be set as specified in Table B-3-16, item 7.

Bit 36 toggles each time the common usage GICB capability report (Register 17_{16}) changes. To avoid the generation of too many broadcast capability report changes, Register 17_{16} is sampled at approximately one minute intervals to check for changes. The setting of this bit is therefore dynamic.

B.4.2 Transponder Registers 18_{16} to $1C_{16}$ (ICAO Doc 9871, Edition 2, §D.2.4.2)

The bits contained in Registers 18_{16} to $1C_{16}$ indicate the capability of the installation and are therefore specific to the platform on which the transponder is installed.

It is accepted that these bits can be set once the corresponding data has been received by the transponder over a period of time. This can happen at any time and not only during the power-on cycle of the transponder as equipment providing expected information could be powered on later.

Once a bit is set, it remains set until the power-off of the transponder.

B.4.3 Transponder Register 20_{16} (ICAO Doc 9871, Edition 2, §D.2.4.3)

B.4.3.1 Airborne Function

ICAO Annex 10, Volume IV requirements (ICAO Annex 10, Volume IV, §3.1.2.9.1.1) state the following for data in transponder Register 20_{16}:

> *AIS, aircraft identification subfield in MB.* The transponder shall report the aircraft identification in the 48-bit (41 – 88) AIS subfield of MB. The aircraft identification transmitted shall be that employed in the flight plan. When no flight plan is available, the registration marking of the aircraft shall be inserted in this subfield.

Note: *When the registration marking of the aircraft is used, it is classified as 'fixed direct data' (see ICAO Annex 10 Vol. IV, §3.1.2.10.5.1.1). When another type of aircraft identification is used, it is classified as 'variable direct data' (see ICAO Annex 10 Vol. IV, §3.1.2.10.5.1.3)."*

When the aircraft installation does not use an external source to provide the aircraft identification (most of the time it will be the call sign used for communications between pilot and controllers), the text above means that the aircraft identification is considered as variable direct data. It also means that such data characterize the flight condition of the aircraft (not the aircraft itself) and are therefore subject to dynamic changes. It further means that variable direct data are also subject to the following requirement when data become unavailable.

Paragraph §B.2.1 states:

"If data is not available for a time no greater than twice the specified maximum update interval or 2 seconds (whichever is the greater), the status bit (if specified for that field) shall indicate that the data in that field are invalid and the field shall be ZEROed."

Therefore, if the external source providing the aircraft identification fails or delivers corrupted data, transponder Register 20_{16} should be ZEROed. It should not include the registration marking of the aircraft since the airborne installation has initially been declared as providing variable direct data for the aircraft identification.

The loss of the aircraft identification data will be indicated to the ground since transponder Register 20_{16} will be broadcast following its change. If the registration marking of the aircraft was inserted in lieu of the call sign following a failure of the external source, it would not help the ground systems since the registration marking of the aircraft is not the information that was inserted in the aircraft flight plan being used by the ground ATC systems.

In conclusion, the aircraft identification is either fixed (aircraft registration) or variable direct data (call sign). It depends whether the aircraft installation uses a data source providing the call sign; if so, data contained in transponder Register 20_{16} should meet the requirement of the ICAO SARPs. When data becomes unavailable because of a data source failure, transponder Register 20_{16} should contain ALL ZEROs.

B.4.3.2 Ground Considerations

Aircraft identification data can be used to correlate surveillance information with flight plan information. If the data source providing the aircraft identification fails, the aircraft identification information will no longer be available in the surveillance data flow. In this case, the following means could enable the ground system to continue correlating the surveillance and flight plan information of a given target.

If the aircraft identification is used to correlate surveillance and flight plan data, extra information such as the Mode A code, if any, and the ICAO 24-bit aircraft address of the target could be provided to the flight data processing system. This would enable the update of the flight plan of the target with this extra information.

In case the aircraft identification becomes unavailable, it would still be possible to correlate both data flows using (for example) the ICAO 24-bit aircraft address information to perform the correlation. It is therefore recommended that ground systems update the flight plan of a target with extra identification information that is available in the surveillance data flow, e.g., the ICAO 24-bit aircraft address, the Mode A code (if any) or the tail number (if available from transponder Register 21_{16}).

This extra identification information might then be used in lieu of the aircraft identification information contained in transponder Register 20_{16} in case the data source providing this information fails.

B.4.3.3 Register 20_{16} and 08_{16} Implementation Considerations

Detailed implementation requirements for Register 20_{16} are provided in §2.2.24.6. §B.2.1, Table B-2-1, Note 2 provides an introduction to Register 08_{16} implementation. Implementation of Register 08_{16} should also consider the following:

a. If valid Flight Identification data is available, then the data should be used to populate the character subfields in Register 08_{16}.

b. After using Flight Identification data to populate the character subfields in Register 08_{16} in a given power-on cycle, if Flight Identification data becomes invalid or not available, then the last known valid Flight Identification data should be retained and used to continue population of the character subfields in Register 08_{16} for the duration of the power-on cycle.

c. If valid Flight Identification data is not available, but valid Aircraft Registration data is available in a given power-on cycle, then the valid Aircraft Registration data should be used to populate the character subfields in Register 08_{16} for the duration of the power-on cycle.

d. If Register 08_{16} has been populated using Aircraft Registration data in a given power-on cycle, and valid Flight Identification data becomes available, then the Flight Identification data should be used to populate the character subfields in Register 08_{16} for the remainder of the power-on cycle.

e. Once valid Flight Identification data has been used to populate Register 08_{16} in a given power-on cycle, Aircraft Registration data should not be used to populate the character subfields of Register 08_{16}, even if Flight Identification data becomes invalid or not available during the power-on cycle.

B.4.4 Transponder Register 40_{16} (ICAO Doc 9871, Edition 2, §D.2.4.4)

Paragraph §B.4.4.1 gives a general example of what are the different selected altitudes and the relationship with the target altitude and introduces the meaning of the different parameters and notions used in this section.

Paragraphs §B.4.4.2 and §B.4.4.3 provide more detailed information for some specific platforms.

B.4.4.1 General Example for the Loading of Data in Register 40_{16}

Figure B-4-1 provides a general example for the loading of data in Register 40_{16}.

The goal of Figure B-4-1 is to clarify the differences between the FMS selected altitude and the FCU/MCP selected altitude, and also to clarify how the target altitude of the aircraft and the MCP/FCU mode bits are determined depending on the phase of flight in the vertical profile.

Notions and terms used:

- Cleared flight level: Flight level cleared by the controller, i.e., the flight level aircraft should reach and maintain.

- MCP/FCU selected altitude:

  - The Autopilot Flight Director System (AFDS) is more commonly known as autopilot (A/P). Its task is to laterally and vertically control the aircraft when selected by the crew. In general in modern aircraft, the AFDS is a system consisting of several individual Flight Control Computers (FCCs) and a single Flight Control Panel (FCP) mounted directly between the pilots just under the windshield. Fundamentally, the autopilot attempts to acquire or maintain target parameters determined either by manual inputs made by the pilot or by computations from the Flight Management System.

  - MCP: Mode Control Panel is the usual name given on Boeing platforms to the FCP which provides control of the Autopilot, Flight Director, Altitude Alert and Autothrottle System. The MCP is used to select and activate Autopilot Flight Director System (AFDS) modes and establish altitudes, speeds and climb/descent profiles.

  - FCU: Flight Control Unit is similar to MCP but for Airbus platforms.

  - MCP/FCU selected altitude: The altitude set by pilots on the MCP/FCU controlling the auto-pilot system. In the great majority of cases pilots set the MCP/FCU altitude to the altitude cleared by Air Traffic Control (ATC) before engaging a vertical mode. The autopilot will try to reach this MCP/FCU selected altitude using different selectable vertical modes: constant vertical rate (e.g., V/S), Flight Level change at a given airspeed (e.g., FL CH), vertical path given by the FMS (VNAV), and maintain it using the altitude hold mode (ALT HOLD).

Note: *If the aircraft is not equipped with an autopilot this information may be derived from equipment generating an alert when the FL is reached (e.g., altitude alerter system).*

- FMS selected altitude:

  - The Flight Management System (FMS or FMC for Flight Management Computer) is a computer onboard aircraft that controls the navigation, performance, flight planning, and guidance aspects of flight. The FMS navigation component determines where the aircraft is. The FMS performance component calculates necessary performance data. The FMS flight planning component allows for the creation and modification of flight plans. The FMS guidance component issues commands necessary to guide the aircraft along the route programmed into the FMS. The current and programmed paths of the aircraft are monitored three-dimensionally, by flying from waypoint to waypoint and by obeying crossing restrictions.

  - The FMS guidance component will therefore compute selected altitude constraints to be reached at different points. This is known as FMS selected altitude. These selected altitudes are used to control the aircraft in specific modes of autopilot for example when Vertical Navigation mode (VNAV) is selected on MCP/FCU. VNAV mode is the highest level of vertical profile automation, and maximizes fuel economy.

- Target altitude: this is the next altitude at which the aircraft will level-off if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its altitude.

  - The target altitude may be:

    - The MCP/FCU selected altitude when the autopilot is directly controlled by command entered by the crew.

    - The FMS selected altitude when in VNAV or similar modes.

    - The current altitude.

    - Unknown.

- MCP/FCU mode bits:

  - VNAV indicates when a VNAV or equivalent mode in which the A/P is controlled by FMS is selected.

  - ALT HOLD indicates when A/P Alt Hold mode is selected. It does not correspond to a general altitude capture and does not cover VNAV hold situation.

  - Approach indicates that a mode to capture ILS localizer and glide slope is engaged.

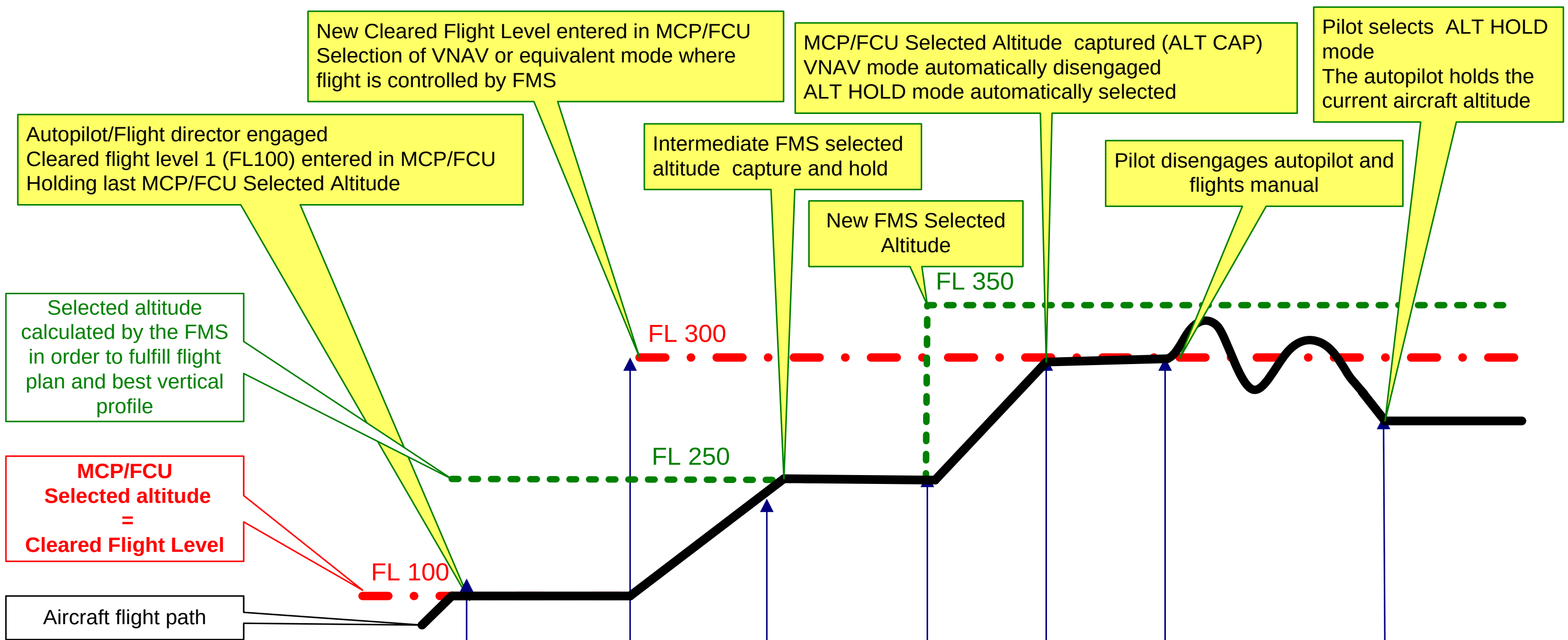
- Priority of MCP/FCU selected altitude on FMS selected altitude:

  The MCP/FCU selected altitude is the altitude that the aircraft shall not violate and therefore it has always priority on FMS selected altitude.

EXAMPLE for the loading of data in Register 40Hex

Hypothesis on information available to transponder

The FMS selected altitude (calculated by the FMS) and the target altitude source information are available on aircraft buses (this is not necessary the case today) as well as the MCP/FCU mode bits. Bits 48 and 54 are set to 1 all the time with this hypothesis. The reverse hypothesis would require bits 48-51 and bits 54-56 to be all set to 0 and the FMS selected altitude field to be all zeroed.



Register 40Hex content	MCP/FCU Selected Altitude		100	300	300	300	300	300	300
	FMS Selected Altitude		250	250	250	350	350	350	350
	MCP/FCU Mode bits	Provided	1	1	1	1	1	1	1
		VNAV	0	1	1	1	0	0	0
		Alt Hold	1	0	0	0	1	0	1
		Approach	0	0	0	0	0	0	0
	Target altitude (Unknown, Altitude,FCU/MCP, FMS)		FCU/MCP	FMS	FMS	FCU/MCP	FCU/MCP	unknown	Altitude
Step			1	2	3	4	5	6	7

Figure B-4-1: General Example for the Loading of Data in Register 40_{16}

Explanation of the different steps in Figure B-4-1:

Generally, Figure B-4-1 shows a theoretical sequence of cases which should not be considered as a real operational sequence. For example, some steps may be more realistic when the aircraft is in descent.

Step 1: The MCP/FCU selected altitude has been set to first cleared flight level (FL100). The Autopilot/Flight Director is engaged and the aircraft is holding the latest MCP/FCU selected altitude which has been reached before Step1. The target altitude is the MCP/FCU selected altitude. VNAV mode is not engaged. The FMS selected altitude is not the target altitude.

Step 2: A new clear flight level has been allocated to the aircraft by ATC. The pilot has entered this value into the MCP/FCU resulting in a new MCP/FCU selected altitude. The pilot has engaged the VNAV mode. The aircraft speed/path is determined by the FMS. The FMS contains a flight path with an altitude restriction at a given waypoint (FL250). The FMS selected altitude corresponds to the associated altitude restriction. This FMS selected altitude is less than the MCP/FCU selected altitude and therefore becomes the target altitude to which the aircraft is climbing.

Step 3: There is an altitude restriction associated with a waypoint. The aircraft has captured and is maintaining the FMS selected altitude until crossing the way point. The VNAV mode remains active. In an operational environment, aircrew should also set the MCP/FCU altitude to the intermediate levels on a stepped climb SID if workload permits.

Step 4: The waypoint with restricted altitude is passed. A new FMS selected altitude is now valid. The aircraft resumes its climbing to try to reach this new FMS selected altitude. VNAV mode is still engaged. Although the aircraft is trying to reach the FMS selected altitude (FL350) it will level-off at the MCP/FCU selected altitude which is lower than the FMS selected altitude therefore the selected altitude is the MCP/FCU selected altitude.

Step 5: The MCP/FCU selected altitude is lower than the FMS selected altitude. The aircraft therefore first approaches this MCP/FCU selected altitude which is a limit to not violate. This MCP/FCU altitude is captured and held by the aircraft. This automatically disengages the VNAV mode.

Step 6: The flight crew has disengaged the autopilot and is flying the aircraft manually. The target altitude is not known. However on an operational point of view it must be noted that such mode would not be allowed in regulated airspace unless the aircrew had declared an emergency or had obtained a new ATC clearance. In the latter case the ATC clearance should be entered in the MCP/FCU. It is more probable that this case may happen on a “descent when ready” profile. In all cases the MCP/FCU selected altitude may still be useful because it should be the value used in the altitude alerter.

Step 7: The pilot selects altitude hold (Alt Hold or equivalent mode) making the current altitude equivalent to the target altitude. Note that although MCP/FCU selected altitude could become the same (pilot entering the new flight level in the MCP/FCU) this is not mandatory and therefore only altitude represents with full confidence the level the aircraft is maintaining.

B.4.4.1.1 Target Altitude Summary

If MCP/FCU altitude is between your current altitude and FMS Selected Altitude, then the target altitude is MCP/FCU. If VNAV is engaged and the previous case is not in effect, then FMS is the target altitude. If Alt Hold is selected and the current altitude is not equal to either of the selected altitudes, then target altitude is altitude.

B.4.4.1.2 Possible Uses of Selected Altitude and Target Altitude

1. MCP/FCU selected altitude will be downlinked as an additional read-back in order to check that the cleared flight level has been correctly understood and entered in the airborne system by the pilot.

2. Target altitude and associated mode of flight may be of interest to reduce the Short Term Conflict Alert false alarm rate.

B.4.4.1.3 Target Altitude Implementation Difficulties

It is recognized that all information to determine which altitude is the target altitude or which mode of flight is currently used may not always be available to the transponder in the current airborne implementation. In addition it may be very dependent on the platform. It is therefore preferable to set to ZERO (0) the corresponding bits of Register 40_{16} rather than sending wrong information.

B.4.4.2 Transponder Register 40_{16} on Boeing 747-400, 757 and 767 Aircraft

In order to clarify how selected altitude information from the altitude control panel and target altitude is reported in transponder Register 40_{16}, a mapping has been prepared to illustrate how the status and mode bits can be derived.

Transponder Register bit #	Description	Label
48	Status of mode bits	SSM of 272 and 273
49	Managed Vertical Mode	272 bit 13
50	Altitude Hold Mode	272 bit 9 / 273 bit 19
51	Approach Mode	272 bit 9 / 273 bit 19
54	Status of Target Altitude source bits	SSM of new label (TBD)
55 – 56	Target Altitude source bits	New label (TBD)

The selected altitude from the mode control panel may be obtained from label 102 (source ID 0A1). The status bit may be derived from the SSM of label 102.

B.4.4.3 Setting of the Target Altitude Source Bits (Bits 54 – 56)

These bits should be set as required in Table B-3-64, item 5:

Bit 54 indicates whether the target altitude source bits (55 and 56) are actively being populated.

0 = No source information provided
1 = Source information deliberately provided

Bits 55 and 56, indicate target altitude source:

00 = Unknown
01 = Aircraft altitude
10 = FCU/MCP selected altitude
11 = FMS selected altitude

Aircraft which are not equipped with the logic described in §B.4.3.1 and §B.4.3.2 are not able to determine the target altitude source of the aircraft. In that case bit 54 should be set to ZERO (0) (no source information provided), and bits 55 and 56 should be set to 00 (unknown).

B.4.4.4 Setting of the Reserved Bits (Bits 40 to 47, 52 & 53)

Bits 40 to 47, 52 and 53 of Register 40_{16} “MB” field should be set to ZERO (0).

B.4.5 Transponder Register 50_{16} (ICAO Doc 9871, Edition 2, §D.2.4.5)

When ARINC 429 data is used, the following is an example implementation:

BDS Bit #:	Data Bit #	Description
1	STATUS	1 = Valid Data
2	SIGN	1 = left (left wing down)
3		MSB = 45 degrees
4		
5		Roll Angle
6		ARINC Label 325
7		
8		Range = [-90, +90]
9		
10		
11		LSB = 45 / 256 degrees
12	STATUS	1 = Valid Data
13	SIGN	1 = west (e.g., 315º = 45º)
14		MSB = 90 degrees
15		
16		
17		True Track Angle
18		ARINC Label 313
19		
20		Range = [-180, +180]
21		
22		
23		LSB = 90 / 512 degrees
24	STATUS	1 = Valid Data
25		MSB = 1024 knots
26		
27		
28		Ground Speed
29		ARINC Label 312
30		
31		Range = [0, 2046]
32		
33		
34		LSB = 1024 / 512 = 2 knots
35	STATUS	1 = Valid Data
36	SIGN	1 = minus
37		MSB = 8 degrees per second
38		
39		Track Angle Rate
40		ARINC Label 335
41		
42		Range = [-16, +16]
43		
44		
45		LSB = 8 / 256 degrees per second
46	STATUS	1 = Valid Data
47		MSB = 1024 knots
48		
49		True Air Speed
50		ARINC Label 210
51		
52		Range = [0, 2046]
53		
54		
55		
56		LSB = 1024 / 512 = 2 knots

The status bits are determined as explained in §B.2.2.2. The data is rounded as specified in §B.2.2.2. The encoding accuracy of the data in the subfield is ±½ LSB by rounding.

For ARINC GAMA configuration, label 335 is not used for the track angle rate but for another parameter. For this particular ARINC configuration the track angle rate field should be loaded with ALL ZEROs. In such cases, ground applications can compute the equivalent of the track angle rate thanks to the true air speed and the roll angle information.

B.4.6 Transponder Register 60_{16} (ICAO Doc 9871, Edition 2, §D.2.4.6)

When ARINC 429 data is used, the following is an example implementation:

BDS Bit #:	Data Bit #	Description
1	STATUS	1 = Valid Data
2	SIGN	1 = West (e.g., 315º = 45º)
3		MSB = 90 degrees
4		
5		Magnetic Heading
6		ARINC Label 320
7		
8		Range = [-90, +90]
9		
10		
11		
12		LSB = 90 / 512 degrees
13	STATUS	1 = Valid Data
14		MSB = 512 knots
15		
16		
17		Indicated Air Speed
18		ARINC Label 206
19		
20		Range = [0, 1023]
21		
22		
23		LSB = 512 / 512 = 1 knot
24	STATUS	1 = Valid Data
25		MSB = 2048
26		
27		
28		Mach
29		ARINC Label 205
30		
31		Range = [0, 4092]
32		
33		
34		LSB = 2048 / 512
35	STATUS	1 = Valid Data
36	SIGN	1 = below
37		MSB = 8192 ft/min
38		
39		Barometric Altitude Rate
40		ARINC Label 212
41		
42		Range = [-16384, +16352]
43		
44		
45		LSB = 8192 / 256 = 32 ft/min
46	STATUS	1 = Valid Data
47	SIGN	1 = below
48		MSB = 8192 ft/min
49		
50		Interial Vertical Velocity
51		ARINC Label 365
52		
53		Range = [-16384, +16352]
54		
55		
56		LSB = 8192 / 256 = 32 ft/min

The status bits are determined as explained in §B.2.2.2. The data is rounded as specified in §B.2.2.2. The encoding accuracy of the data in the subfield is ±½ LSB by rounding.

"Barometric Altitude Rate" contains values that are solely derived from barometric measurement. The Barometric Altitude Rate may be very unsteady and may suffer from barometric instrument inertia.

The "Inertial Vertical Velocity" is also providing information on vertical attitude of the aircraft but it comes from equipments (IRS, AHRS) which use different sources used for navigation. The information is a more filtered and smoothed parameter.

Appendix C
Mode-S Specific Services (MSSS)

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C. Mode-S Specific Services (MSSS)

C.1 Introduction

C.1.1 Purpose

This Appendix sets forth minimum operational performance standards for the Mode S Specific Services (MSSS). The MSSS provides a standard communication interface and service through which avionics application processors may exchange data with ground based application processors via the Mode S transponder. Compliance with these standards is required to assure that the Mode S Specific Services characteristics will perform its intended functions satisfactorily under normal operating conditions. Incorporated within these standards are system characteristics that will facilitate the design and implementation of the Mode S Specific Services.

C.1.2 Scope

This Appendix defines the functional requirements for the Mode S Specific Services, and describes the architecture within which the Mode S Specific Services entity will operate. It does not define data link applications that will be supported by Mode S and other data links.

C.1.3 Mode-S Application Entity (AE) / Transponder Interface Management

The Mode S Application Entity (AE) controls the interface to the Mode S Transponder based on information received from the Higher-Layer Entity (HLE) via the Specific Services Entity (SSE) interface, and based on the internal processing requirements of the AE. Additionally, the Mode S AE receives information via the AE/Transponder interface, which must be processed and transferred to the HLE.

The Mode S AE must also establish and maintain the local relationship between the Mode S Aircraft AE and the various Mode S Ground AEs with which it communicates.

Note: *In the framework of these Mode S Specific Services referenced herein, the Mode S AE supports the functionality required to support implementation of these capabilities. A Mode S ADLP would provide the Mode S AE functionality required, but in the context of this Appendix, it does not necessitate the need for full Mode S ADLP capabilities.*

C.2 Design Requirements

C.2.1 Basic Operations

The Mode S Specific Services **shall** offer the following types of services to the user.

a. Mode S Protocol service: The Mode S Protocol (MSP) service transfers limited data between air and ground application peers, using extremely low overhead. The MSP service does not use diagnostic, flow control, or interrupt procedures as defined within ISO 8208. Such mechanisms should be defined within the application entities.

b. Broadcast Protocol service (Comm-A, Comm-B): The Mode S subnetwork is capable of supporting information delivery to all interrogators participating in data link operations for that aircraft through the use of the Broadcast Comm-B protocol. It is also able to receive messages directed to all transponders through the use of the Broadcast Comm-A protocol.

c. Ground Initiated Comm-B service: The Mode S subnetwork allows for the access of prestored data within the Mode S transponder (256 register set) from ground application entities.

C.2.2 Mode-S Specific Services Entity (SSE) Interface Requirements

C.2.2.1 General

The AE **shall** support the accessing of Mode S Specific Services through the provision of one or more separate AE interfaces.

Note: *Mode S Specific Services consist of the broadcast Comm-A and Comm-B, Ground Initiated Comm-B (GICB) and MSP.*

C.2.2.2 Functional Capability

The AE **shall** support the accessing of Mode S Specific Services through the provision of one or more separate AE interfaces.

Message and control coding via the MSSS interface **shall** support all of the capabilities specified in §B.2.2.6.

Note: *Mode S Specific Services consist of the broadcast Comm-A and Comm-B, Ground Initiated Comm-B (GICB) and MSP.*

C.2.2.3 Mode-S Specific Services Architecture

The Mode S Specific Services architecture, as shown in Figure C-2-1, provides for the top level architecture, which is inclusive of the Mode S Specific Services Entity (SSE), the SSE interface to a higher layer application process, frame processing function, Mode S transponder (aircraft component), and Mode S interrogator (ground component). Between air and ground, the peer interface entities are identified as being, SSE Data, Frames, and Mode S link protocol (RF).

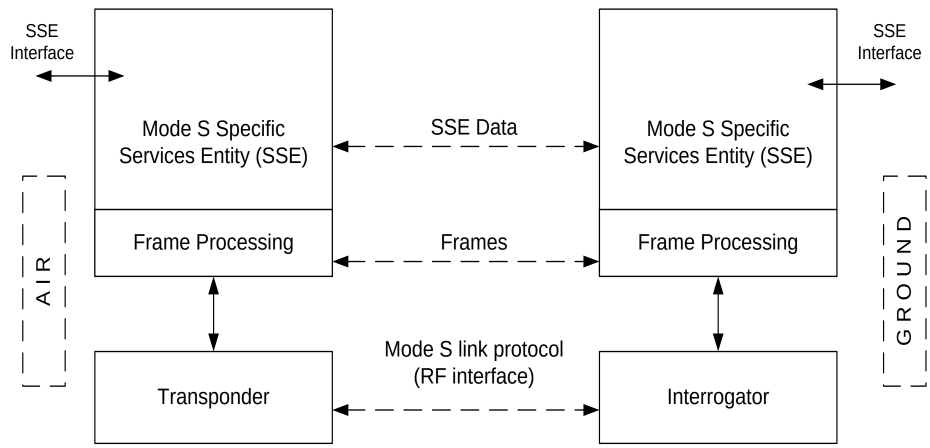


Figure C-2-1: Mode-S Specific Services Architecture

C.2.2.4 Transponder to Application Entity (AE) Interface

The AE **shall** accept an indication of protocol type from the transponder in connection with data transferred from the transponder to the AE. This **shall** include the following types of protocols:

a. Surveillance interrogation,

b. Comm-A interrogation,

c. Comm-A broadcast interrogation,

d. Uplink ELM.

The AE **shall** also accept the II code of the interrogator used to transmit the surveillance, Comm-A or uplink ELM.

Note: *Transponders will not output all call and Traffic Alert and Collision Avoidance System (TCAS) information on this interface. Use of SI code limited to Comm-A and Comm-A broadcast interrogations.*

The AE **shall** accept control information from the transponder indicating the status of downlink transfers. This **shall** include:

a. Comm-B closeout,

b. Comm-B broadcast time out,

c. Downlink ELM closeout.

The AE **shall** have access to current information defining the communication capability of the Mode S transponder with which it is operating. This information **shall** be used to generate the Data Link Capability Report.

C.2.2.5 Application Entity (AE) to Transponder Interface

The AE **shall** provide an indication of protocol type to the transponder in connection with data transferred from the AE to the transponder. This **shall** include the following types of protocols:

a. Ground initiated Comm-B,

b. Air initiated Comm-B,

c. Multisite directed Comm-B,

d. Comm-B broadcast,

e. Downlink ELM,

f. Multisite directed downlink ELM.

The AE **shall** also provide:

1. The II code for transfer of a multisite directed Comm-B or multisite directed downlink ELM, and

2. The Comm-B Data Selector (BDS) code for a ground initiated Comm-B.

Note: *Use of SI code limited to Ground-initiated Comm-B and Comm-B Broadcast.*

C.2.2.6 Mode-S Specific Services Processing

Mode S Specific Services **shall** be processed by an entity in the application termed the Mode S Specific Services entity.

C.2.2.6.1 Processing

Notes:

1. *There are three Mode S Specific Services protocol types; broadcast, GICB and MSP.*

2. *Control data can consist of information permitting message length, BDS code used to access the data format for a particular register, and aircraft 24 bit address.*

C.2.2.6.1.1 Downlink Processing

Note: *This section describes the processing of control and message data received from the Mode S Specific Services interface.*

C.2.2.6.1.1.1 General

The AE **shall** be capable of receiving control and message data from the Mode S Specific Services interface(s) and sending delivery notices to this interface. The control data **shall** be processed to determine the protocol type and the length of the message data. When a message or control data provided at this interface are erroneous (i.e., incomplete, invalid or inconsistent) the AE **shall** discard the message and deliver an error report at the interface.

Note: *The diagnostic content and the error reporting mechanism are a local issue.*

C.2.2.6.1.1.2 Broadcast Processing

The control and message data **shall** be used to format the Comm-B broadcast message as specified in §C.2.2.6.4 and transfer it to the transponder.

C.2.2.6.1.1.3 Ground-Initiated Comm-B (GICB) Processing

The GICB service consists of defined data available on board the aircraft being put into one of the 255 transponder registers (each with a length of 56 bits) in the Mode S transponder at specified intervals by a serving process, e.g., airborne collision avoidance system (ACAS), aircraft data link processor (ADLP), or an application entity (AE). 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.

The assignment of Registers **shall** be as specified in Appendix B.

C.2.2.6.1.1.4 MSP Processing

The MSP message length, channel number (M/CH, §C.2.2.6.2.1) and optionally the interrogator II code **shall** be determined from the control data. The MSP message content **shall** be extracted from the received message data. If the message length is 26 bytes or less, the SSE **shall** format an air initiated Comm-B message for transfer to the transponder using the Short Form MSP Packet (see §C.2.2.6.2.1). If the message length is 27 to 159 bytes and the transponder has adequate downlink ELM capability, the SSE **shall** format an ELM message for transfer using the Short Form MSP Packet. If the message length is 27 to 159 bytes and the transponder has a limited downlink ELM capability, the SSE **shall** format multiple Long Form MSP Packets (see §C.2.2.6.2.2) using ELM messages as required utilizing the L bit and the M/SN Fields for association of the packets. If the message length is 27 to 159 bytes and the transponder does not have downlink ELM capability, the SSE **shall** format multiple long form MSP packets using air initiated Comm-B messages, as required utilizing the L bit and M/SN fields for association of the packets. Different frame types **shall** never be used in the delivery of an MSP message. Messages longer than 159 bytes **shall** be discarded. The assignment of downlink MSP channel numbers **shall** be as specified in Table C-2-2.

For an MSP, a request to send a packet **shall** cause the packet to be multisite-directed to the interrogator II code as specified in control data. If no II code is specified, the packet **shall** be down linked using the air-initiated protocol. A message delivery notice for this packet **shall** be provided to the Mode S specific interface when the corresponding closeout(s) have been received from the transponder. If a closeout has not been received from the transponder in Tz seconds, as specified in Table C-2-2, the MSP packet **shall** be discarded. This **shall** include the cancellation in the transponder of any frames associated with this packet. A delivery failure notice for this message **shall** be provided to the Mode S Specific Services interface.

Table C-2-2: MSP Channel Number Assignments

Uplink Channel Number	Assignment
0	Not Valid
1	Specific Services Management
2	Traffic Information Service
3	Ground-to-Air Alert
4	Ground Derived Position
5	TCAS Sensitivity Level Control
6	Ground-to-Air Service Request
7	Air-to-Ground Service Response
8 – 63	Unassigned
Downlink Channel Number	**Assignment**
0	Not Valid
1	Specific Services Management
2	Unassigned
3	Data Flash
4	Position Request
5	Unassigned
6	Ground-to-Air Service Response
7	Air-to-Ground Service Request
8 – 63	Unassigned

Table C-2-3: Broadcast Identifier Number Assignments

Uplink Broadcast Identifier	Assignment
00_{16}	Not Valid
01_{16}	Differential GPS Correction
30_{16}	Not Valid
31_{16}	TCAS/ACAS (RA Broadcast)
32_{16}	TCAS/ACAS (ACAS Broadcast)
Others	Unassigned
Downlink Broadcast Identifier	**Assignment**
00_{16}	Not Valid
02_{16}	Traffic Information Service
10_{16}	Data Link Capability Report
20_{16}	Aircraft Identification
30_{16}	TCAS/ACAS (RA Broadcast)
FE_{16}	Update Request
FF_{16}	Search Request
Others	Unassigned

C.2.2.6.1.2 Uplink Processing

Note: *This section describes the processing of Mode S Specific Services messages received from the transponder.*

C.2.2.6.1.2.1 General

The AE **shall** be capable of receiving Mode S Specific Services messages from the transponder via Frame Processing. The AE **shall** be capable of delivering the messages and the associated control data at the specific services interface. When the resources allocated at the interface are insufficient to accommodate the output data, the AE **shall** discard the message and deliver an error report at this interface.

C.2.2.6.1.2.2 Broadcast Processing

If the received message is a broadcast Comm-A, as indicated by control data received over the transponder/AE interface, the broadcast ID and user data (see §C.2.2.6.4) **shall** be forwarded to the Mode S Specific Services interface, along with the control data that identifies this as a broadcast message. The assignment of uplink broadcast identifier numbers **shall** be as specified in Table C-2-3.

C.2.2.6.1.2.3 MSP Processing

If the received message is an MSP, as indicated by the packet format header (see §C.2.2.6.2), the User Data Field of the received MSP packet **shall** be forwarded to the Mode S Specific Services interface together with control data that identifies this as an MSP message. L bit processing (see §C.2.2.6.3) **shall** be performed as required. The assignment of uplink MSP channel numbers **shall** be as specified in Table C-2-3.

C.2.2.6.2 MSP Packet Formats

C.2.2.6.2.1 Short Form MSP Packet

The format for this packet **shall** be as follows:

DP:1	MP:1	M/CH:6	FILL 1:0 or 6	UD:v

Data Packet: Type (DP) This field **shall** be set to ZERO (0).

MSP Packet Type (MP): This field **shall** be set to ZERO (0) to indicate that this is a Short Form MSP Packet.

MSP Channel Number (M/CH): The field **shall** be set to the channel number derived from the SSE control data (Table C-2-5).

Fill Field. (FILL1: 0 or 6): The Fill length **shall** be 6 bits for a downlink SLM Frame. Otherwise the Fill length **shall** be ZERO (0).

User Data (UD): The User Data Field **shall** contain message data received from the Mode S Specific Services interface.

C.2.2.6.2.2 Long Form MSP Packet

The format for this packet **shall** be as follows:

DP:1	MP:1	SP:2	L:1	M/SN:3	FILL 2:0 or 2	M/CH:6	UD:v

Data Packet Type (DP): This field **shall** be set to ZERO (0).

MSP Packet Type (MP): This field **shall** be set to ONE (1) to indicate that this is not a Short Form MSP Packet.

Supervisory Packet (SP): This field **shall** be set to ZERO (0).

L Field (L): A value of one **shall** indicate that the packet is part of an L bit sequence with more packets in the sequence to follow. A value of ZERO (0) **shall** indicate that the sequence ends with this packet.

MSP Sequence Number Field (M/SN): This field **shall** be used to detect duplication in the delivery of L bit sequences. The first packet in an L bit sequence **shall** be assigned a sequence number of ZERO (0). Subsequent packets **shall** be numbered sequentially. A packet received with the same sequence number as the previously received packet **shall** be discarded.

MSP Channel Number (M/CH): The field **shall** be set to the channel number derived from the SSE control data (Table C-2-5).

User Data (UD): The User Data Field **shall** contain message data received from the Mode S Specific Services interface.

C.2.2.6.3 L-Bit Processing

L bit processing **shall** be performed only on the Long Form MSP Packet.

Upon receipt of a long form MSP Packet the AE **shall** construct the User Data Field by:

a. Verifying that the packet order is correct using the M/SN Field (see §C.2.2.6.2.2).

b. Assuming that the User Data Field in the MSP Packet is the largest number of integral bytes that is contained within the frame.

c. Associating each User Data Field in an MSP Packet received with a previous User Data Field in an MSP Packet that has an L bit value of ONE (1).

d. Truncating the assembled User Data Field to 151 bytes if necessary.

Note: *Truncation of the user data field is a condition that cannot be reported.*

e. If an error is detected in the processing of an MSP packet, the packet **shall** be discarded.

In the processing of an L bit sequence, the AE **shall** discard any MSP packets that have duplicate M/SN values. The AE **shall** discard the entire L bit sequence if a long form MSP Packet is determined to be missing by use of the M/SN Field.

The packets associated with any L bit sequence whose reassembly is not completed in Tm seconds (Table C-2-4) **shall** be discarded.

C.2.2.6.4 Broadcast Format

The first byte of the broadcast MA field **shall** contain the broadcast identifier as specified in Table C-2-1.

C.2.2.7 Frame Processing

C.2.2.7.1 Uplink Frames

C.2.2.7.1.1 Uplink SLM Frames

An uplink SLM frame **shall** be composed of up to 4 selectively addressed Comm-A segments.

Note: *Each Comm-A segment (MA Field) received by the AE is accompanied by the first 32 bits of the interrogation that delivered the segment. Within these 32 bits is the 16 bit Special Designator (SD) Field.*

C.2.2.7.1.1.1 SD Field

When the Designator Identification (DI) Field (bits 14-16) has a code value of 1 or 7, the Special Designator (SD) Field (bits 17-32) of each Comm-A interrogation **shall** be used to obtain the Interrogator Identifier Subfield (IIS, bits 17-20) and the Linked Comm-A Subfield (LAS, bits 30-32). The action to be taken **shall** depend on the value of LAS. The contents of LAS and IIS **shall** be retained and **shall** be associated with the Comm-A message segment for use in assembling the frame as indicated below. All fields other than the LAS Field **shall** be as defined in §2.2.19.2.1.1.

SD FIELD

For DI=1

					→ TMS	
IIS	**MBS**	**MES**	**LOS**	**RSS**	**Spare**	**LAS**
17 → 20	21 → 22	23 → 25	26	27 → 28	29	30 → 32

For DI=7

						→ TMS	
IIS	**RRS**	**Spare**	**LOS**	**Spare**	**OVC**	**Spare**	**LAS**
17 → 20	21 → 24	25	26	27	28	29	20 → 32

Figure C-2-2: The SD Field Structure

C.2.2.7.1.1.2 LAS Coding

The three bit LAS subfield **shall** be coded as specified in Table C-2-4.

Table C-2-4: LAS Subfield Coding

LAS (decimal)	**Meaning**
0	Single segment
1	Linked, 1st segment
2	Linked, 2nd but not final segment
3	Linked, 3rd but not final segment
4	Linked, 4th and final segment
5	Linked, 2nd and final segment
6	Linked, 3rd and final segment
7	Unassigned

C.2.2.7.1.1.3 Single Segment SLM Frame

If LAS=0, the data in the MA Field **shall** be considered a complete frame and **shall** be made available for further processing.

C.2.2.7.1.1.4 Multiple Segment SLM Frame

The AE **shall** accept and assemble linked 56 bit Comm-A segments associated with all 16 possible Interrogator Identifier (II) codes. Correct linking of Comm-A segments **shall** be achieved by requiring that all Comm-A segments have the same value of IIS. If LAS=1 through 6 the frame **shall** consist of two to four Comm-A segments as specified in the following:

Note 1: *The number of linked Comm-A's is limited to four because longer linked Comm-A transmissions would result in inefficient utilization of the Mode S link, as well as slow frame delivery. Longer frames can be transferred more efficiently using the ELM protocol.*

Initial Segment: If LAS = 1, the MA Field **shall** be assembled as the initial segment of an SLM frame. In this case, the initial segment **shall** be stored until all segments of the frame have been received or the frame is canceled.

Intermediate Segment: If LAS = 2 or 3, the MA Field **shall** be assembled in numerical order as an intermediate segment of the SLM frame. It **shall** be associated with previous segments containing the same value of IIS.

Final Segment: If LAS = 4, 5 or 6, the MA Field **shall** be assembled as the final segment of the SLM frame. It **shall** be associated with previous segments containing the same value of IIS.

Note 2: *A two segment linked Comm-A will consist of an initial segment (LAS=1) and a final segment (LAS=5).*

Frame Completion: The frame **shall** be considered complete and **shall** be made available for further processing as soon as all segments of the frame have been received.

Frame Cancellation: An incomplete SLM frame **shall** be canceled if one or more of the following conditions apply:

a. A new initial segment (LAS=1) is received with the same value of IIS. In this case, the new initial segment **shall** be retained as the initial segment of a new SLM frame.

b. The sequence of received LAS codes (after the elimination of duplicates) is not contained in the following list:

1. LAS = 0
2. LAS = 1,5
3. LAS = 1,2,6
4. LAS = 1,6,2
5. LAS = 1,2,3,4
6. LAS = 1,3,2,4
7. LAS = 1,2,4,3
8. LAS = 1,3,4,2
9. LAS = 1,4,2,3
10. LAS = 1,4,3,2

c. Tc (seconds) have elapsed since the last Comm-A segment with the same value of US was received. See Table C-2-6.

Segment Cancellation

A received segment for an SLM frame **shall** be discarded if it is an intermediate or final segment and no initial segment has been received with the same value of IIS.

Segment Duplication

If a received segment duplicates a currently received segment number with the same value of IIS, the new segment **shall** replace the currently received segment.

Note 3: *The action of the Mode S link protocols may result in the duplicate delivery of Comm-A segments.*

C.2.2.7.1.2 Uplink ELM Frame

An uplink ELM frame **shall** consist of from 20 to 160 bytes and **shall** be transferred from the interrogator to the transponder using the protocol defined in §2.2.20. The first 4 bits of each uplink ELM segment (MC Field) **shall** contain the Interrogator Identifier (II) code of the Mode S interrogator transmitting the ELM. The AE **shall** check the II code of each segment of a completed uplink ELM. If all of the segments contain the same II code, the II code in each segment **shall** be deleted and the remaining message bits retained as user data for further processing. If all of the segments do not contain the same II code, the entire uplink ELM **shall** be discarded.

Note: *An uplink ELM frame consists of 2 to 16 associated Comm C segments, each of which contains the 4 bit II code. Therefore, the capacity for packet transfer is 19 to 152 bytes per uplink ELM frame.*

C.2.2.7.2 Downlink Frames

Note: *Data is transferred from an AE to a "Ground Application Entity" using downlink frames.*

C.2.2.7.2.1 Downlink SLM Frame

A downlink SLM frame **shall** be composed of up to 4 Comm-B segments. The MB Field of the first Comm-B segment of the frame **shall** contain a 2 bit Linked Comm-B Subfield (LBS, bit 1 and 2 of the MB Field). This subfield **shall** be used to control linking of up to 4 Comm-B segments.

Note: *The LBS uses the first two bit positions in the first segment of a multi or single segment downlink SLM frame. Hence, 54 bits are available for Mode S packet data in the first segment of a downlink SLM frame. The remaining segments of the downlink SLM frame, if any, have 56 bits available.*

C.2.2.7.2.1.1 LBS Coding

Linking **shall** be indicated by the coding of the LBS subfield of the MB Field of the initial Comm-B segment of the SLM frame.

The coding of LBS **shall** be as specified in Table C-2-5.

Table C-2-5: LBS Subfield Coding

LBS (decimal)	**Meaning**
0	Single segment
1	Initial segment of a two-segment SLM frame
2	Initial segment of a three-segment SLM frame
3	Initial segment of a four-segment SLM frame

C.2.2.7.2.1.2 Linking Protocol

In the Comm-B protocol, the initial segment **shall** be transmitted using the air initiated or multisite directed protocols. The LBS Field of the initial segment **shall** indicate to the ground the number of additional segments to be transferred (if any). Before the transfer of the initial segment to the transponder, the remaining segments of the SLM frame (if any) **shall** be transferred to the transponder for transmission to the interrogator using the ground initiated Comm-B protocol. These segments **shall** be accompanied by control codes that cause the segments to be inserted in ground initiated Comm-B Registers 02_{16}, 03_{16} or 04_{16}, associated respectively with the second, third, or fourth segment of the frame.

Closeout of the air initiated segment that initiated the protocol **shall** not be performed until all segments have been successfully transferred.

Notes:

1. *The linking procedure including the use of the ground initiated Comm-B protocol is performed by the AE.*

2. *When the Mode S interrogator detects a non-zero LBS code in an air initiated or multisite directed Comm-B segment, it can proceed immediately with the ground initiated Comm-B protocol and request the remaining segments of the SLM frame. When it has received all of the segments, it closes out the air initiated or multisite directed segment that began the linked Comm-B protocol.*

3. *This linking protocol, as well as the linked Comm-A protocol, is transparent to the transponder.*

C.2.2.7.2.1.3 Directing SLM Frames

If the SLM frame is to be multisite directed, the AE **shall** determine the II code of the Mode S interrogator or cluster of interrogators that **shall** receive the SLM frame.

C.2.2.7.2.2 Downlink ELM Frame

Downlink ELM frames **shall** be used to deliver messages greater than 128 bytes and **shall** be formed using the protocol defined in §2.2.20.2.

Note: *A downlink ELM consists of 1 to 16 associated Comm D segments.*

C.2.2.7.2.2.1 Directing ELM Frames

If the ELM frame is to be multi-site directed, the AE **shall** determine the II code of the Mode S interrogator or cluster of interrogators that **shall** receive the ELM frame.

C.2.2.7.2.3 Delivery Status

AE Frame Processing **shall** accept an indication from the transponder that a specified downlink frame that was previously transferred to the transponder has been closed out as specified in §2.2.19.1.12.4 and §2.2.20.2.3.

C.2.2.7.2.4 Interrogator Identifier

AE Frame Processing **shall** accept from the transponder, along with the data in each uplink SLM or ELM, the Interrogator Identifier (II) code of the interrogator that transmitted the frame. AE Frame Processing **shall** transfer to the transponder the II code of the interrogator or cluster of interrogators that **shall** receive a multi-site directed frame.

C.2.2.7.2.5 Frame Cancellation

AE Frame Processing **shall** be capable of canceling downlink frames previously transferred to the transponder for transmission but for which a closeout has not been indicated. If more than one frame is stored within the transponder, the cancellation procedure **shall** be capable of canceling the stored frames selectively.

C.2.2.8 System Timers

The values for timers referenced in this specification **shall** conform to the values given in Table C-2-6.

Table C-2-6: AE Mode-S Subnetwork Timers

Timer Name	Timer Label	Nominal Value	Reference
L-Bit Delivery	Tm	120 seconds	§C.2.2.6.3
Interrogator Link	Tz	30 seconds	§C.2.2.6.1.1.4
Link Frame Cancellation	Tc	60 seconds	§C.2.2.7.1.1.4

*Tolerance for all timers **shall** be ±1 percent.*
*Resolution for all timers **shall** be 1 second.*

C.3 Mode-S Specific Services Test Procedures

The test procedures set forth below constitute a satisfactory method of determining required Mode S Specific Services performance. Although specific test procedures are cited, it is recognized that other methods may be preferred. Such alternate methods may be used if the manufacturer can show that they provide at least equivalent information. Therefore, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

C.3.1 General Characteristics

The test configuration (Figure C-3-1) provides a means of validating the information content of any message received from the Aircraft Application Entity (AAE), as well as the Ground Application Entity (GAE), which is processed and managed by both the Aircraft – Specific Services Entity (A-SSE), and the Ground – Specific Services Entity (G-SSE).

The test configuration should be capable of generating or accepting messages in the form of MSPs, Broadcast and GICB. The test configuration should be able to format and populate the data content for MSSS type messages.

The test configuration should be capable of generating the entire content of a Long and Short Mode S uplink message, and accept the entire content of a Long and Short downlink message according to the following:

(1) Long Mode S messages are 112 bits, encoded per §2.2.14 and §2.2.19. Short Mode S messages are 56 bits, also coded according to §2.2.14 and §2.2.19. When required, the coding of these messages is contained in the appropriate test procedure of this Appendix.

(2) For uplink Extended Length Messages (ELM)s, the test configuration should be able to convey a control field called Interrogator Identification Subfield (IIS) to the A-SSE independently of the messages described in (1) above.

(3) The test configuration should be able to convey delivery status of Mode S downlink messages to the A-SSE independently of the messages described in (1) above.

(4) The test configuration should be able to accept from the A-SSE a Mode S frame cancellation message independently of the messages described in (1) above.

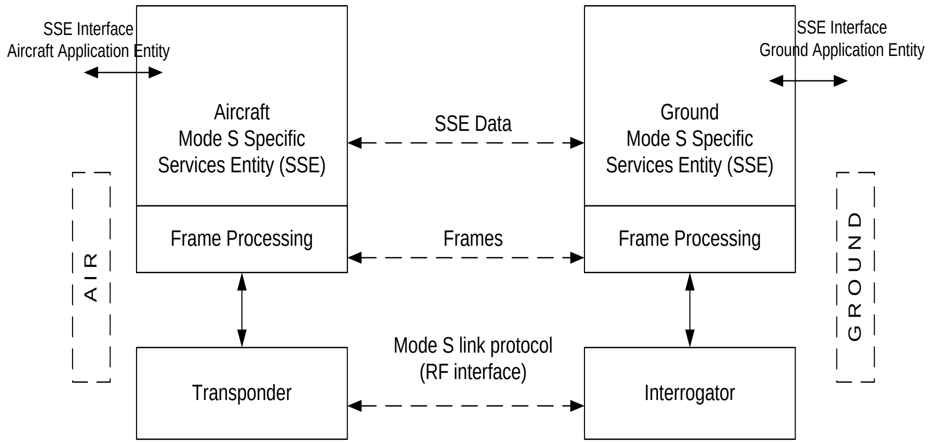


Figure C-3-1: Mode-S Specific Services Test Configuration

C.3.2 Detailed Test Procedures

C.3.2.1 Downlink Processing

C.3.2.1.1 Broadcast Processing

(§C.2.2.6.1.1.1 – General)
(§C.2.2.6.1.1.2 – Broadcast Processing)
(§C.2.2.6.4 – Broadcast Format)

Objective: This test is designed to validate the downlink broadcasting function of the MSSS, which includes broadcast processing and formatting of the broadcast messages.

Step 1 Generate two 56 bit downlink broadcast messages. The 56-bit message data field will consist of an alternating one zero pattern and alternating zero one pattern for alternate packets. Send the two broadcast messages to the A-SSE.

Step 2 At the G-SSE, verify that the transponder has generated two broadcast Comm-B segments whose MB Fields are equal to the message data fields of the broadcast messages. Verify format and content of the broadcast message.

Step 3 If supported by the interface, generate a downlink broadcast message from the A-SSE with the data field length greater than 56 bits. Verify that an error message to the A-SSE is generated, and that no request for a Comm-B downlink appears at the RF interface.

C.3.2.1.2 MSP Processing

(§C.2.2.6.1.1.4 – MSP Processing)
(§C.2.2.6.2.1 – Short Form MSP Packet)
(§C.2.2.6.2.2 – Long Form MSP Packet)
(§C.2.2.7.2.3 – Delivery Status)

Objective: This test is designed to validate the downlink MSP processing function of the MSSS, which includes MSP processing, delivery status and formatting of the short form and long form MSP packets. The tests cover both SLM and ELM capabilities of the Mode S Transponder.

SLM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 From the AAE, generate the following MSP packets:

Group	# of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	5 bytes	1 segment	48 – 41
b.	4	12 bytes	2 segments	52 – 49
c.	4	19 bytes	3 segments	56 – 53
d.	4	26 bytes	4 segments	60 – 57
e.	3	29 bytes	See text	63 – 61
f.		165 bytes		61

Step 3 For groups “a” through “d,” extract all Comm-B segments, and follow each with a closeout, as necessary. Verify that the control codes are DP=0, MP=0 (indicating the Short form MSP) and M/CH field corresponds to the selected MSP packet group (M/CH=48 to 41 for group a., M/CH = 52 to 49 for group b., etc.). Verify that the status of each downlink is sent to the A-SSE.

Note: *The packet from group “e” is oversize and cannot be transmitted in entirety. This portion of the test requires the A-SSE to use Long Form MSP packets with L bit assembly.*

Step 4 Verify that the first Comm-B message contains 26 bytes of user data identical to the first 26 bytes of the UD Field in the original MSP message, and the L bit is set. Verify that the second Comm-B message contains one segment with the MB Field identical to the last three bytes of user data in the original MSP message, and the L bit is not set.

Step 5 Send the data from group f to the A-SSE. Verify that no request for Comm-B downlink appears at the A-SSE RF interface.

ELM Capable

Step 1 Repeat the group e test described in the previous paragraph with the condition that the oversize packets are to be sent in total using downlink ELM containing Short MSP packets.

C.3.2.2 Uplink Processing

C.3.2.2.1 Broadcast Processing

(§C.2.2.6.1.2.1 – General)
(§C.2.2.6.1.2.2 – Broadcast Processing)
(§C.2.2.6.4 – Broadcast Format)
(§C.2.2.7.2.4 – Interrogator Identifier)

Objective: This test is designed to validate the uplink broadcasting function of the MSSS, which includes broadcast processing, interrogator identifier, and formatting of the broadcast messages.

Step 1 Send twelve uplink Comm-A Broadcast messages divided into two groups of six interrogations. The first group will be uplinked with a UF Field = 20 and the second group with UF = 21. Within each group of six interrogations, the 56 bit MA fields will contain a combination of the following bit patterns: all ones, all zeros, alternating ones and zeros and alternating zeros and ones. For each frame, set DI = 1 or 7, IIS = 15, and SD (except IIS) = 0, and provide an indication that the frame is an unlinked Comm-A (LAS = 0).

Step 2 Verify that the data delivered to the A-SSE interface contains the 56 bits of data in the MA field, the 32 bits Mode S frame header information, the II code, the broadcast ID and an indication that the frames are Comm-A broadcast frames.”

C.3.2.2.2 MSP Processing

(§C.2.2.6.1.2.3 – MSP Processing)
(§C.2.2.6.2.1 – Short Form MSP Packet)
(§C.2.2.6.2.2 – Long Form MSP Packet)

Objective: This test is designed to validate the uplink MSP processing function of the MSSS, which includes MSP processing and formatting of the short form and long form MSP packets. The tests cover both SLM and ELM capabilities of the Mode S Transponder. The test uplinks several packets on different Mode S MSP channel numbers. The A-SSE is required to reformat Short and Long MSP packets into message and control data for the AE Separate Interface.

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 Send the following MSP messages to the AAE from the G-SSE interface:

Group	# of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	6 bytes	1 segment	48 – 41
b.	4	13 bytes	2 segments	52 – 49
c.	4	20 bytes	3 segments	56 – 53
d.	4	27 bytes	4 segments	60 – 57
e.	3	29 bytes	See text	63 – 61

Step 3 Verify that the A-SSE forwards the contents of the UD fields, as well as a means for identifying the packets as MSP data, to the AAE interface.

Step 4 In case e), send to the A-SSE 2 Mode S linked Comm-A frames containing 2 linked Mode S Long Form MSP Packet on the selected MSP channel number. The first packet will have L bit set to one and contain 26 bytes of user data. The second frame will have L bit set to zero and contain 3 bytes of user data. Make sure the A-SSE forwards the contents of the UD Field in its entirety and correct order to the AAE.

Step 5 If ELM capability is available, repeat Step e) but this time send a Mode S Short Form MSP packet to the A-SSE containing 29 bytes of data in the UD Field. Verify that the A-SSE forwards the contents of the UD Field as a means for identifying the packet as MSP data, to the AAE.

C.3.2.3 Frame Tests

C.3.2.3.1 Uplink SLM Frames

(§C.2.2.7.1.1 – Uplink SLM Frame)
(§C.2.2.7.1.1.1 – SD Field)
(§C.2.2.7.1.1.2 – LAS Coding)
(§C.2.2.7.1.1.3 – Single Segment SLM Frame)
(§C.2.2.7.1.1.4 – Multiple Segment SLM Frame)
(§C.2.2.7.2.5 – Frame Cancellation)

Objective: This test is designed to validate the uplink frame function of the MSSS, which includes processing of the SLM frame, SD field, LAS coding, the frame cancellation function, and the management of single segment and multiple segment SLM frames.

Single Segment SLM Frame

Step 1 From the G-SSE interface, generate 4 unlinked Comm-A frames containing Mode S Short Form MSP Packets having uniquely identifiable data in each of the 6 byte UD fields.

Step 2 Send this data to the A-SSE using MSP Channel Number 48 for the first frame, 47 for the second frames, etc., and use II = 6 for all frames.

Step 3 Verify that the A-SSE accepts control and message data from the transponder interface indicating 4 unlinked Comm-A segments with IIS = 6 and LAS = 0 in each case. Also, verify also that the A-SSE forwards the content of the UD Field to the A-SSE interface as well as a means for identifying the packets as MSP data, to the A-SSE interface.

Note: *If this test is to be performed in conjunction with Mode S transponder validation, the message field must be duplicated exactly in the Mode S RF interrogation, and uplink formats 20 and 21 must both be used.*

SD Field
LAS Coding
Frame Cancellation
Multiple Segment SLM Frame

This test requires the transmission of linked Comm-A segments over MSP channels.

In order for the A-SSE to reformat the frames, it is necessary to have segment number one contain the Short Form MSP Packet header.

Linked Comm-A messages can be canceled either whole or in part if the segments are not correctly received as determined by the LAS Field.

Step 1 Generate the following table of uplink frame data. Uniquely identify the data in the MA fields of each segment by using recognizable sequences of bit and/or byte patterns. All segments should be delivered by the same sensor II code, that is sensor 1, except frames 13 and 15 which should be delivered by sensor number 2.

Step 2 Send the following sequence of frames to the A-SSE:

LAS CODING

Frame	1	2	3	4	5	6	Notes
1.	1	0	0	0	1	0	Initial and Final Segments
2.	0	1	1	1	0	0	Two intermediate and one final segment; no initial segment
3.	1	1	0	0	0	1	Initial intermediate and final segments
4.	1	1	1	0	0	0	Initial and intermediate segments; no final segment
5.	1	0	0	0	0	1	Initial, third/final segments, no second segment
6.	1	1	1	0	0	0	Initial and intermediates; no final segment
7.	0	0	0	0	0	0	Delay Tc Plus one second
8.	0	0	0	1	0	0	Final segment for frame 6
9.	1	1	1	0	0	0	Initial and intermediate segments
10.	0	0	1	1	0	0	Duplicate and final segment for frame 9
11.	1	1	1	1	0	0	All 4 segments complete
12.	1	0	0	0	0	0	Initial segment IIS=1
13.	1	0	0	0	0	0	Initial segment IIS=2
14.	0	0	0	0	1	0	Final segment IIS=1
15.	0	0	0	0	1	0	Final segment IIS=2
16.	1	0	0	0	0	1	First and final segment
17.	0	1	0	0	0	0	Second segment

Step 3 Send each frame at 10 second intervals, except frame 7. After sending frame 6, wait at least Tc plus one second before sending frame 8. Thereafter, continue with 10 second intervals.

Step 4 Verify that frames 1, 3, 11, 12/14, 13/15, and 16/17 are sent to the A-SSE interface. Verify the 0.25 second reformatting time requirement and the data content for completeness and proper order.

Step 5 Frames 9 and 10 should comprise a complete linked Comm-A. However, segment 3 is duplicated in frame 10 and should be discarded. Verify that frames 9 and 10 are sent to the A-SSE interface. Verify from the length and content that the duplicate segment has been discarded.

Step 6 Frames 2, 4, 5, 6 and 8 should all be discarded; no message data should result. Each of these frames meets one of the conditions of §C.2.2.7.1.1.4 for uplink frame cancellation.

Link Frame Cancellation Timer Tc

Step 1 Generate two Short Form MSP packets with a 27 byte UD Field to fit into a four segment linked Comm-A message. The content of the UD Field will be a 1 in the first byte, 2 in the second byte, etc. Set II = 1 for all segments.

Step 2 Send only the first three Comm-A segments of the first frame to the A-SSE. Impose a delay of Tc minus two seconds, then send the final segment.

Step 3 Verify that the A-SSE forwards to the AAE interface a MSP message with a 27 byte UD Field in correct order and content.

Step 4 Repeat the process just described and transmit the first three Comm-A segments of the second frame. However, this time impose a delay of Tc plus two seconds between the transmission of the third and the final Comm-A segments. Verify that there is no output to the AAE.

C.3.2.3.2 Uplink ELM Frames

(§C.2.2.7.1.2 – Uplink ELM Frame)

Objective: This test is designed to validate the uplink frame function of the MSSS, and is intended to demonstrate that the A-SSE can receive segments of an ELM. ELM protocol is strictly a transponder issue; the A-SSE has no part in the message handling until the transponder sends a complete ELM.

The data content of each of the segments of the ELM will be identical to the transponder MC Fields after the receipt of an ELM. The bit pattern contained in the MC Field should permit each segment's data to be uniquely identified. Note that the first four bits of each uplink ELM MC Field contains the II code of the sensor. Therefore, there are 76 bits of User Data in each uplink ELM segment. All segments should be delivered by the same sensor 1, code.

Step 1 Send the following table of ELM frames (UF = 24) containing the Short Form of MSP packets, to the A-SSE at the transponder interface:

Group	# of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	1	18 bytes	2 segments	2
b.	1	27 bytes	3 segments	3
c.	1	37 bytes	4 segments	4
d.	1	46 bytes	5 segments	5
e.	1	56 bytes	6 segments	6
f.	1	65 bytes	7 segments	7
g.	1	75 bytes	8 segments	8
h.	1	84 bytes	9 segments	9
i.	1	94 bytes	10 segments	10
j.	1	103 bytes	11 segments	11
k.	1	113 bytes	12 segments	12
l.	1	122 bytes	13 segments	13
m.	1	132 bytes	14 segments	14
n.	1	141 bytes	15 segments	15
o.	1	151 bytes	16 segments	16

Step 2 Verify also that the A-SSE forwards the contents of the UD fields of the MSP packets and a means for identifying the packet as MSP data, to the AAE interface.

Negative Uplink ELM Frame Test

The A-SSE must discard the entire uplink ELM if all of the segments do not contain the same II code.

Step 1 Repeat the previous test with data from group “a” of the test but send the last segment with an II code different from the II code contained in the first segment.

Step 2 Verify that no output is generated to the A-SSE.

C.3.2.3.3 Downlink SLM Frames

(§C.2.2.7.2.1 – Downlink SLM Frame)
(§C.2.2.7.2.1.1 – LBS Coding)
(§C.2.2.7.2.1.2 – Linking Protocol)
(§C.2.2.7.2.1.3 – Directing SLM Frames)
(§C.2.2.7.2.3 – Delivery Status)

Objective: This test is designed to validate the downlink frame function of the MSSS, which includes processing of the SLM frame, LBS coding, linking protocol, directing and delivery status of SLM frames. This test requires the transmission single and linked Comm-B segments over MSP channels.

SLM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field. Set II=1 for all packets in this section.

Step 2 Send the following MSP messages to the A-SSE from the AAE interface:

Group	# of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	8	5 bytes	1 segment	48 – 41
b.	4	12 bytes	2 segments	52 – 49
c.	4	19 bytes	3 segments	56 – 53
d.	4	26 bytes	4 segments	60 – 57
e.	3	29 bytes	See text	63 – 61

Step 3 Extract each Comm-B segments from the A-SSE and send Comm-D close-outs, as necessary. Verify the A-SSE sends an indication of the downlink delivery status to the AAE. Verify the correct association of LBS value with the number of segments delivered and that the M/CH field decrements correctly.

Note: *Since the transponder is not downlink ELM capable, the packets from group "e" will be sent via Comm-B segments with MSP L bit procedures.*

Step 4 Verify that the first Comm-B message from group e consists of 4 segments and contains 26 bytes of data in the MB Field(s) and that the second Comm-B message contains one segment with three bytes of data in the MB Field.

C.3.2.3.4 Downlink ELM Frame

(§C.2.2.7.2.2 – Downlink ELM Frame)
(§C.2.2.7.2.2.1 – Directing ELM Frame)

Objective: This test is designed to validate the downlink frame function of the MSSS, which includes processing of the ELM frames. This test requires the transmission of ELM segments over MSP channels.

ELM Capable

Step 1 Uniquely identify the UD fields of each MSP packet by using recognizable sequences of bit and/or byte patterns. One method for uniquely identifying each packet for this test is to insert the MSP channel number in the UD Field.

Step 2 Send the following MSP messages to the A-SSE from the AAE interface:

Group	# of Packets	UD Field Length	Packet Size	MSP Channel Numbers
a.	1	9 bytes	1 segment	1
b.	1	19 bytes	2 segments	2
c.	1	29 bytes	3 segments	3
d.	1	39 bytes	4 segments	4
e.	1	49 bytes	5 segments	5
f.	1	59 bytes	6 segments	6
g.	1	69 bytes	7 segments	7
h.	1	79 bytes	8 segments	8
i.	1	89 bytes	9 segments	9
j.	1	99 bytes	10 segments	10
k.	1	109 bytes	11 segments	11
l.	1	119 bytes	12 segments	12
m.	1	129 bytes	13 segments	13
n.	1	139 bytes	14 segments	14
o.	1	149 bytes	15 segments	15
p.	1	159 bytes	16 segments	16

Step 3 Extract the Comm-D segments from the A-SSE and send Comm-D close-outs, as necessary. Verify the A-SSE sends an indication of the downlink delivery status to the AAE interface. At the GAE interface, verify the correct association of the ND value with the number of segments delivered and that the M/CH field increments correctly for each packet.

C.3.2.4 MSP Operations

(§C.2.2.6.1.1.4, §C.2.2.6.1.2.3 – MSP Processing)
(§C.2.2.6.3 – L-bit Processing)
(§C.2.2.8 – System Timers)

Objective: This test is designed to validate the MSP operations by using L-bit linking, MSP processing and System Timers in associated with these operations.

Step 1 Send 4 bytes of CONTROL MESSAGE data from the AAE interface on channel 1. Verify at the G-SSE interface that the A-SSE has sent a Mode S short form MSP packet on channel 1.

Step 2 Send 42 bytes of CONTROL MESSAGE DATA from the AAE interface on channel 1. At the G-SSE, verify that two Mode S MSP packets (long form) are received from the A-SSE on channel 1. The first frame will have L bit set to one and contain 26 bytes of user data. The second frame will have L bit set to zero and contain 16 bytes of user data.

Step 3 Send a Mode S frame containing a Mode S MSP (short form) Packet to the A-SSE on channel 2. Fill the UD Field with five bytes of the bit pattern 01010101. At the A-SSE interface, verify the reception of a CONTROL MESSAGE DATA on channel 2.

Step 4 Generate 42 bytes of Control Message Data from the G-SSE interface on MSP channel 1 in a total of 2 MSP packets (Long Form). The first MSP packet will have L-bit set to 1 and contain 26 bytes of User Data. The second MSP packet will have L-bit set to 0 and contain 16 bytes of User Data. At the A-SSE interface, verify that an MSP packet (Long Form) is received from the A-SSE on channel 1.

C.3.2.5 L-Bit Linking

(§C.2.2.6.3 – L-bit Processing)
(§C.2.2.8 – System Timers)

Objective: This test is designed to validate the L-bit linking function of the MSSS for long form MSP channels, and the use of the Tm timer for L-bit linking.

The Long Form MSP Packet test procedures are designed to test the A-SSE's ability to link Mode S Long Form MSP Packets when the packet size is greater than 28 bytes and the transponder has no downlink ELM capability.

Step 1 Use a selected MSP number, fill the Used Data Field with 32 bytes of the bit pattern 01010101. At the G-SSE interface, verify that two mode S long form MSP packets are received on the selected MSP channel from the A-SSE. The first frame will have L bit set to one and contain 26 bytes of user data. The second frame will have L bit set to zero and contain 6 bytes of user data.

Step 2 Send two Mode S Comm-A frames containing a linked Mode S Long Form MSP Packet to the A-SSE on a MSP channel number. Fill the UD Field with 26 bytes and 6 bytes respectively with the bit pattern 10101010. At the A-SSE interface, verify that a Mode S long form MSP packet is received from the AAE. Verify the UD Field for content and order.

L-bit Delivery Timer (Tm)

Step 1 From the GAE, create 2 long form MSP packets for delivery to the AAE. The first packet will have 26 bytes of user control data and L-bit set to ONE (1). The seconds packet will have 16 bytes of user control data and L-bit set to ZERO (0) for a complete sequence.

Step 2 After sending the first packet, send the second packet within the Tm time period. At the AAE interface, verify the receipt of this constructed packet containing 42 bytes of user control data in correct order and content.

Step 3 Repeat the process to generate the long form MSP packets again to the A-SSE, except this time, send the second packet after Tm time period. This allows the A-SSE to discard the complete sequence since the expiration of the Tm timer for L-bit sequencing.

Verify that there’s no related output for this transaction at the AAE interface.

C.3.2.6 Link Frame Cancellation Timer (Tc)

(§C.2.2.7.2.5 – Frame Cancellation)
(§C.2.2.8 – System Timers)

Objective: This test is designed to validate the Tc frame cancellation timer of the frame processing function.

Step 1 From the GAE, generate two Short Form MSP packets with a 27 byte UD Field to fit into a four segment linked Comm-A message. The content of the UD Field will be a 1 in the first byte, 2 in the second byte, etc. Set II = 1 for all segments.

Step 2 Send only the first three Comm-A segments of the first frame to the A-SSE. Impose a delay of Tc minus two seconds, then send the final segment.

Step 3 Verify that the A-SSE receives an MSP message with a 27 byte UD Field in correct order and content.

Step 4 Repeat the process just described and transmit the first three Comm-A segments of the second frame. However, this time impose a delay of Tc plus two seconds between the transmission of the third and the final Comm-A segments. Verify that there is no output to the AAE.

C.3.2.7 Interrogator Link Timer (Tz)

(§C.2.2.6.1.1.4 – MSP Processing)
(§C.2.2.8 – System Timers)

Objective: This test is designed to validate the Tz interrogator link timer of the MSSS.

Step 1 From the GAE, generate a short form MSP packet for delivery to the AAE (data content can be any).

Step 2 For this downlink, do not allow for a closeout from the G-SSE. This will force the Tz timer in the A-SSE to start its countdown for the non-closeout action.

Step 3 After 30 seconds elapse, verify that there's no output in the form of the MSP packet at the GAE, since the packet would have been discarded by the A-SSE due to the Tz timeout.

C.4 Dataflash Application

C.4.1 Introduction

Eurocontrol has defined a Table of parameters available from aircraft systems that will be downlinked via Mode S to ATC ground systems. This information is intended to provide the ATC systems with more information to improve knowledge, amongst other things, on the aircraft's current status and its short term intent. The parameters are called Downlink Aircraft Parameters (DAPs). They can be acquired via the Mode S system by the use of either one of two Mode S protocols as follows:

Ground initiated Comm B (GICB) which requires regular interrogation of the aircraft to extract the parameter.

Dataflash is a contract-based service specified by ICAO in the Manual on Mode S Specific Services (ICAO Doc 9871, Appendix A). It relies on the aircraft system, announcing in its Mode S replies to surveillance interrogations, that a parameter in a contracted transponder register has changed according to rules agreed in the contract. It therefore does not require regular interrogations to check the status of the parameter.

C.4.2 The Choice of Protocol

Data that needs to be updated every few scans of the ground radar will normally be extracted by the ground system using the GICB protocol. To use this protocol to acquire data which does not necessarily change very often, results in a lot of interrogations and replies which provide the same information as the previous transaction, therefore causing unnecessary interference on the radio frequency channel.

Dataflash is a much more radio frequency channel efficient protocol that can be used to extract information that may not change very often, and Eurocontrol states using Mode S will therefore need to use this protocol.

C.4.3 EUROCAE Documentation

The Mode S transponder functions and protocols are fully covered by Eurocae ED-73C MOPS, and the Mode S Aircraft Data Link Processor (ADLP) functions and protocols by the ED-82A MOPS. The latter, however does not include MOPS for the Dataflash function because Dataflash is a Mode S Specific Services Application, and as such is not covered by the Mode S Subnetwork standards or MOPS.

A characteristic for a Mark 4 transponder has now been published in ED-86, requiring the Dataflash function to be part of the Mark 4 transponder. To locate Dataflash elsewhere would require a lot of data already residing in the transponder to be shipped out to the Dataflash function for monitoring and back in again when action is required. This would result in an unnecessary aircraft wiring and data-bus load. In order to permit full certification of such a transponder, Dataflash MOPS are required.

If the Dataflash application is implemented in an ADLP and a failure of the ADLP occurs, the only possible recovery mechanism is a power up restart to ensure that the ADLP is in the initialization state. Failure of the ADLP **shall** not impair the surveillance function of the transponder.

In the case of a single ADLP connected to two transponders, it **shall** be possible to switch over to the standby transponder without affecting the ADLP states.

C.4.4 Dataflash Requirements

All the requirements of Uplink MSP channel 6 when the Service Request header is set to 1 and those of Downlink MSP channel 3 **shall** be met as specified in ICAO Doc 9871, Appendix A.

The detailed requirements are stated in §C.4.6.

C.4.5 Document Precedence

If there is any conflict between this Appendix and ICAO Doc 9871, Appendix A, the latter takes precedence.

C.4.6 Uplink MSP Channel 6 (Ground-to-Air Request)

C.4.6.1 Purpose

To provide a means of requesting access to services supported by the aircraft. When implemented, bit 6 of the register accessed by Register $1D_{16}$ **shall** be set to ONE (1).

C.4.6.2 Format

The request **shall** be transferred in an uplink MSP packet with the channel number set to 6 and, in the case of a long form MSP packet, with SP set to ZERO (0). The first byte of the user data field contains a service request (SR) header. The contents and format of the service request are specified by the application.

C.4.6.3 SR Header Assignments

The decimal value of SR **shall** be interpreted as follows:

0	Unassigned
1	Dataflash
2	Local System Management
3 to 255	Unassigned

C.4.6.4 Dataflash Request Format

The purpose of Dataflash service is described in §C.4.7.1. The format of the user data field is shown in Table C-4-1. The user data field of the requesting MSP packet **shall** contain the decimal value of "ONE" in the first byte (SR header), followed by one or more requests for Dataflash services. Each request **shall** contain a two byte Dataflash request header (DH), followed by a one byte field to define the minimum time interval permitted between reports (MT field), a four bit field to determine the event criterion (EC field), a four bit field to determine stable time (ST field), and if indicated in EC, a Change Quanta field (CQ) and a Change Threshold (CT) field. The 4 bit ST field **shall** indicate the decimal value in seconds, how long the changed data has been stable before a message **shall** be initiated. ALL ZEROs in the Dataflash header (DH) **shall** indicate that there are no more Dataflash requests in the packet. When an MSP packet is completely filled with Dataflash requests, or when there is not sufficient room in the packet for another Dataflash request header, it **shall** be assumed that the Dataflash request sequence is complete.

A single Dataflash contract relates to a single contract number for a single register for a particular II code. This meets the requirement that multiple Dataflash services, with different DH values for each II code, can be established simultaneously with the same aircraft. These may be modified or discontinued independently of each other. All aircraft equipment and installations **shall** support 16 Dataflash contracts. All aircraft Dataflash equipment and installations originally certified after 1 January 2001 **shall** support 64 Dataflash contracts.

Note: *When a request has been accepted by the aircraft system a data flash response will be triggered immediately regardless of thresholds or event criteria. If no response is received in 30 seconds then a check should be made that the aircraft is still available on roll call, and if so a new request should be generated. In order to avoid repeated Dataflash requests that produce no response, the number of such requests (N) should be limited (N=3).*

When a new contract request is received for a contract already in existence, the old contract **shall** be discontinued and replaced immediately by the latest one.

C.4.6.5 Dataflash Header (DH) 16 Bits

The 16 bit DH field is divided into three subfields separated by 3 currently unassigned bits 14 through 16 (see Table C-4-1).

C.4.6.5.1 Contract Number Subfield (CNS) 4-Bits.

(Bits 9 to 12 of the Uplink MSP 6 User Data Field)

This subfield **shall** be interpreted as a contract number permitting 16 different contracts to be associated with the register specified by the BDS1 and BDS2 codes of this contract request.

Contract numbers available are 0 to 15.

C.4.6.5.2 Request Data Subfield (RDS) 1-Bit.

(Bit 13 of the Uplink MSP 6 User Data Field)

This subfield **shall** indicate whether or not the contents of the register being monitored by the requested contract must be sent in the MSP Packets on Downlink channel 3 that are sent each time the criterion for the contract is met.

The subfield **shall** be interpreted as follows:

RDS = 0 Send only bits 1 to 40 of the user data field on Downlink MSP 3 when the contract criterion is met.

RDS = 1 Send bits 1 to 96 of the user data field on Downlink MSP 3 when the contract criterion is met.

Note: *RDS only indicates the length of the user data field in Downlink MSP3 when responding with a value zero in the CI field (see §C.4.7.4.3.1).*

C.4.6.5.3 BDS1 and BDS2 Codes of the Register for Which the Contract is Required. 8 Bits.

(Bits 17 to 24 of the Uplink MSP 6 User Data Field)

BDS1 and BDS2 codes are specified in Annex 10 Volume IV.

C.4.6.6 Minimum Time (MT) 8 Bits

The decimal value of the 8 bit MT field represents the minimum time in seconds that **shall** elapse after a report has been event triggered and sent to the transponder, before a new report can be initiated. The report sent to the transponder **shall** always be the most current data available.

C.4.6.7 Event Initiation

Event initiation **shall** be controlled by the two following fields.

C.4.6.7.1 Event Criterion Field (EC) 4 Bits

These are the four bits following the MT field. If multiple events occur within a single register being monitored by a Dataflash contract, (e.g., if more than one parameter shows a significant change) only one message **shall** be triggered.

The decimal value of the EC field **shall** be interpreted as follows:

0 = No report required, discontinue service for the contract specified in the DH field.

1 = Report any change.

2 = 56 bit change field (CQ) follows ST. Only report changes to bits indicated by a "ONE" in CQ.

3 = 56 bit field CQ follows ST. For each parameter report all status changes and all changes of the parameter greater than the quantum value indicated in the same units and resolution of the field in CQ corresponding to that parameter. A zero in the field in CQ corresponding to the parameter indicates that no reports are required.

4 = 112 bits CQ plus CT follow ST. The first 56 bits are as for the EC value 3 above. The second 56 bits are the CT field indicating a threshold value in the field corresponding to the parameter. Report all changes above the threshold where the value in CQ gives the change quantum.

5 = 112 bits of CQ and CT follow ST. Same as for the EC value 4 above except: report all changes below the threshold.

6 = 112 bits of CQ and CT follow ST. Same as for ECS values 4 and 5 above except report only when the threshold is crossed (in either direction).

7 to 14 = Not currently assigned.

15 = Cancel all contracts for the II code in this request.

C.4.6.7.2 Stable Time Field (ST) 4 Bits

These are the four bits following the EC field. The decimal value of ST **shall** indicate in seconds, how long the changed data have been stable to within the change quanta specified in CQ field, before a message **shall** be initiated. A value of ZERO (0) in this subfield **shall** indicate that there is no minimum stable time and any change immediately initiates a message. The significance of the ST will differ slightly depending upon which EC mode is being used. In particular, for EC modes 4 & 5, regarding stability whilst above/below a threshold, if a parameter value remains above/below the defined threshold for greater than the ST time then a Dataflash **shall** be generated even if the value does not remain stable to within one quantum. Subsequent quantum changes which are stable for greater than the ST time **shall** generate further Dataflash messages until the value falls below / rises above the threshold.

C.4.6.8 Change Fields – Change Quanta (CQ) and Change Threshold (CT)

These fields **shall** be present when indicated in EC. For a GICB service (i.e., for DH from 1 to 255 inclusive), CQ **shall** be contained in bits 41 to 96 of the MSP 6 User Data Field. CT when required **shall** be contained in bits 97 to 152 of the MSP 6 User Data Field. The quantum value in the CQ field **shall** be in the same units and resolution as those specified for the register being monitored and it specifies the amount by which the parameter **shall** change, from its value at the initialization of the contract, and thereafter from the value last reported by a Dataflash response on downlink channel MSP 3.

Table C-4-1: Request for Dataflash Register monitoring Service Mode S SLM Frame Containing (Uplink MSP Channel 6)

MSP (6) USER DATA FIELD Bits 1 to 40

	DP = 0 (1 BIT)	UPLINK MSP HEADER (1 BYTE)
	MP = 0 (1 BIT)	
	M/CH = 6 (6 BITS)	
1		
2		
3		
4	SERVICE REQUEST (SR)	
5		
6		
7		
8		
9	CONTRACT	
10	NUMBER	
11	SUBFIELD	
12	(CNS)	
13	REQUEST DATA (RDS)	
14	NOT	
15	ASSIGNED	DATAFLASH
16		HEADER
17		(DH)
18	BDS1	
19	CODE	
20		
21		
22	BDS2	
23	CODE	
24		
25		
26		
27	MINIMUM	
28	TIME (MT)	
29	INTERVAL	
30		
31		
32	LSB = 1 second	
33		
34	EVENT	
35	CRITERION (EC)	
36		
37		
38	STABLE TIME (ST)	
39		
40	LSB = 1 second	

MSP (6) USER DATA FIELD Bits 41 to 96 (if required)

41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	CHANGE
61	QUANTA
62	FIELD (CQ)
63	
64	
65	
66	
67	
68	
69	
70	
71	
72	
73	
74	
75	
76	
77	
78	
79	
80	
81	
82	
83	
84	
85	
86	
87	
88	
89	
90	
91	
92	
93	
94	
95	
96	

MSP (6) USER DATA FIELD Bits 97 to 152 (if required)

97	
98	
99	
100	
101	
102	
103	
104	
105	
106	
107	
108	
109	
110	
111	
112	
113	
114	
115	
116	CHANGE
117	THRESHOLD
118	FIELD (CT)
119	
120	
121	
122	
123	
124	
125	
126	
127	
128	
129	
130	
131	
132	
133	
134	
135	
136	
137	
138	
139	
140	
141	
142	
143	
144	
145	
146	
147	
148	
149	
150	
151	
152	

The last byte of the final MA field shall always be unassigned

Note: *See Annex 10 Volume III §5.2.7.3 for specification of MSP Packets.*

C.4.7 Downlink MSL Channel 3. Dataflash Service

C.4.7.1 Purpose

Dataflash is a service which announces the availability of information from air-to-ground on an event triggered basis. This is an efficient means of downlinking information which changes occasionally and unpredictably. When implemented, bit 31 of the Register accessed by Register $1D_{16}$ **shall** be set to ONE (1).

C.4.7.2 Service Initiation and Termination

The Dataflash service **shall** be initiated or discontinued by a service request. It is received on uplink MSP channel 6 with a decimal value of ONE in the service request (SR) header which is contained in the first byte of the user data field. This indicates that the rest of the user data field contains Dataflash request. On the receipt of such a request a Dataflash message from the register concerned with the request, **shall** immediately be made available and announced to the ground regardless of the setting of the RDS field in the contract request and of any event criteria.

The response **shall** be as follows:

1. When the requested register is being serviced, the contract **shall** be established and an MSP Packet as in Table C-4-2 **shall** be announced to the ground on MSP channel 3. The CI field **shall** be set to a value of 1. The message **shall** be used by the ground system to confirm that the service has been initiated.

2. If the requested register is not being serviced the contract **shall** not be established. This **shall** be indicated by announcing the MSP Packet on Downlink MSP channel 3 to the ground as shown in Table C-4-2, and with a value of 2 in the CI field.

3. If the maximum number of contracts that can be supported are already established then the new contract **shall** be refused. This **shall** be indicated by announcing to the ground an MSP Packet on Downlink channel 3, as shown in Table C-4-2, and with a value of 3 in the CI field.

4. In the case of a request from the ground to terminate the service for a particular register the termination of the service **shall** be confirmed by announcing to the ground, an MSP Packet on Downlink channel 3, as shown in Table C-4-2, and with a value of 4 in the CI field.

5. In the case of a request from the ground to terminate the service for all contracts to a particular II code. The termination of the service **shall** be confirmed by announcing to the ground, an MSP Packet on Downlink channel 3, as shown in Table C-4-2, and with a value of 5 in the CI field.

6. When the register service fails for an established contract, the contract **shall** be terminated by the airborne application. This **shall** be indicated by announcing an MSP Packet on Downlink channel 3, to the ground, as shown in Table C-4-2, and with a value of 7 in the CI field. Register service **shall** be deemed to have

failed when any of the parameters specified to be monitored in the negotiation of the contract is not being updated at the specified minimum rate.

7. When a contract is refused due an invalid value of the EC field in the contract request this **shall** be indicated by announcing an MSP Packet on Downlink channel 3 to the ground as shown in Table C-4-2, and with a value of 15 in the CI field.

8. If any message is not extracted from the transponder by a ground interrogator within 30 seconds the aircraft subnetwork cancels the message and generates a delivery failure notice (i.e., the Tz timer expires) which is delivered to the aircraft MSP service provider. When a delivery failure notice is received the service **shall** be automatically terminated by the Dataflash function with no indication to the ground system.

Note: *This is to prevent the transponder message queues being blocked when the ground interrogator stops supplying the message extraction service, either due to a fault or loss of cover. It is the responsibility of the ground application to monitor the Dataflash service taking this into account.*

9. When the transponder has not been selectively interrogated by a Mode S interrogator with a particular II code for 60 seconds (this is determined by monitoring the IIS subfield in all accepted Mode S interrogations), all Dataflash contracts related to that II code **shall** be cancelled with no indication to the ground system.

C.4.7.3 Service Provision

On the reception of a Dataflash request the requested parameters **shall** be monitored and transferred to the ground using the Mode S air initiated protocols directed to the II code that was contained in the requesting interrogation. In order to prevent the flooding of the transponder with Dataflash messages, an upper limit of ten messages in a six seconds period **shall** be imposed. When the limit of ten messages within a six seconds period is reached, further messages **shall** be queued until they can be sent. Messages queued in this way **shall** respond with a CI field value of 6.

If after initiating a Dataflash message to the ground, the change criterion is met again prior to the message being entered into the transponder for announcement, the message is considered stale and **shall** be replaced by the most up to date information.

C.4.7.4 Downlink Message Structure

The information **shall** be transferred in a downlink MSP packet with the channel number M/CH = 3. The format is shown in Table C-4-2.

The first two bytes of the User Data (UD) field **shall** contain a Dataflash header (DH), which are identical to the DH field that was contained in the request for the service.

C.4.7.4.1 Bits 17 to 31 of UD form the II code Contract Report Field in which each bit **shall** indicate that at least one contract is active with the II code which the bit represents when it is set to a ONE, otherwise there are no active contracts with that II code.

C.4.7.4.2 Bits 32 to 36 of UD are not assigned.

C.4.7.4.3 **Bits 37 to 40 of UD form the Contract Information (CI) field which shall be interpreted as follows:**

CI Field Value	Meaning
0	Response to existing contract
1	New contract established
2	New contract not accepted due to no register data service
3	New contract not accepted due to maximum number of contracts already being serviced.
4	Contract terminated for the DH in this response due to a request from the ground.
5	All contracts terminated for the II code that delivered the MSP Packet having an EC value of 15 that requested this response. Response has been queued due to the limit of ten Dataflash messages in a six seconds period. Contract terminated due to failure of the register data service.
8 to 14	Unassigned
15	New contract not accepted due to invalid number in EC field of requesting uplink MSP Packet.

C.4.7.4.3.1 When the CI field is equal to ZERO the response **shall** be as requested by the RDS field in the Dataflash header of the contract (see §C.4.6.5.2). When the CI field is not equal to ZERO the response **shall** only contain bits 1 to 40 of the user data field on downlink MSP 3 (see Table C-4-2).

C.4.7.5 Data Extraction by Mode-S Ground Stations

The Dataflash transaction **shall** be announced as a downlink frame in replies to interrogations UF 4, 5, 20, or 21. The transaction announced **shall** be either a single segment Comm B frame, or a two segment Comm B frame, as requested by the contract negotiation. The Air Directed Comm B first segment **shall** contain the MSP header, Dataflash header, and control information for that particular contract. In the case of a contract for a single segment response, if the data is required, it is acquired by the ground station extracting the register in question directly.

Table C-4-2: Dataflash for Register Monitoring Service (Mode-S Frame for Downlink MSP Channel 3)

MSP (3) USER DATA FIELD Bits 1 to 40 | **MSP (3) USER DATA FIELD Bits 41 to 96**

	LINKED COMM B SUBFIELD (LBS) (2 BITS)		41	
			42	
	DP = 1 (1 BIT)		43	
	MP = 0 (1 BIT)		44	
			45	
			46	
	M/CH = 3 (6 BITS)		47	
		MSP	48	
		HEADER	49	
			50	
			51	
			52	
	FILL 1 = 0 (6 BITS)		53	
			54	
			55	
			56	
1	CONTRACT		57	
2	NUMBER		58	
3	SUBFIELD		59	
4	(CNS)		60	
5	REQUEST DATA SUBFIELD (RDS)		61	
6	NOT		62	
7	ASSIGNED		63	
8		DATAFLASH	64	REGISTER
9		HEADER (DH)	65	MESSAGE
10	BDS1		66	CONTENT
11	CODE		67	
12			68	
13			69	
14	BDS2		70	
15	CODE		71	
16			72	
17	II=1		73	
18	II=2		74	
19	II=3		75	
20	II=4		76	
21	II=5		77	
22	II=6		78	
23	II=7	II CODE	79	
24	II=8	CONTRACT	80	
25	II=9	REPORT (CR)	81	
26	II=10		82	
27	II=11		83	
28	II=12		84	
29	II=13		85	
30	II=14		86	
31	II=15		87	
32			88	
33			89	
34	NOT ASSIGNED		90	
35			91	
36			92	
37			93	
38	CONTRACT		94	
39	INFORMATION (CI)		95	
40			96	

Note: See Annex 10 Volume III §5.2.7.3 for specification of MSP Packets

C.4.7.6 Data flash Requirement/Test Cross Reference Table

Table C-4-3 lists all requirements and gives the test section Procedures which test each requirement.

Table C-4-3: Dataflash Requirements/Test Cross-Reference

Requirement Paragraph No	Headline	Test Chapter Paragraph No	Related test
§C.4.6	Uplink MSP channel 6		headline
§C.4.6.1	Purpose	§C.4.8.2.1	Procedure 1 Step 1
§C.4.6.2	Format		uplink requirement
§C.4.6.3	SR header assignments	§C.4.8.2.2	Procedure 2 Step 2
§C.4.6.4	Dataflash request format	§C.4.8.2.2	Procedure 2 Step 2
§C.4.6.5	Dataflash header (DH) 16 bits		introduction
§C.4.6.5.1	Contract number Subfield (CNS)	§C.4.8.2.4	Procedure 4 Step 1
§C.4.6.5.2	Request Data Subfield (RDS)	§C.4.8.2.2	Procedure 2 Step 2
§C.4.6.5.3	BDS 1 and BDS2 codes of the register for which the contract is required.	§C.4.8.2.2	Procedure 2 Step 2
§C.4.6.6	Minimum time (MT)	§C.4.8.2.5	Procedure 5 Steps 1, 2
§C.4.6.7	Event Initiation		introduction
§C.4.6.7.1	Event Criterion field (EC) -a. EC = 0	§C.4.8.2.3	Procedure 3 Step 1
	-b. EC = 1	§C.4.8.2.2	Procedure 2 Step 1
	-c. EC = 2	§C.4.8.2.6	Procedure 6 Step 1
	-d. EC = 3	§C.4.8.2.6	Procedure 6 Step 2 Procedure 6 Step 3
	-e. EC = 4	§C.4.8.2.6	Procedure 6 Step 4
	-f. EC = 5	§C.4.8.2.6	Procedure 6 Step 5
	-g. EC = 6	§C.4.8.2.6	Procedure 6 Step 6
	-h. EC = 7-14	§C.4.8.2.6	Procedure 6 Step 9
	-i. EC = 15	§C.4.8.2.6	Procedure 6 Step 7
§C.4.6.7.2	Stable time (ST) field	§C.4.8.2.7	Procedure 7 Step 1
§C.4.6.8	Change fields - -a. Change Quanta (CQ)	§C.4.8.2.6	Procedure 6 Step 2 (LSB) Procedure 6 Step 3 (MSB)
	-b. Change Threshold (CT)	§C.4.8.2.6	Procedure 6 Step 4
Table C-4-1	MSP packet User Data (MSP 6)		implicitly tested
§C.4.7	Downlink MSP Channel 3 Dataflash Service		headline
§C.4.7.1	Purpose		introduction
§C.4.7.2	Service initiation and termination		implicitly tested
	1. Initiation action (contract established)	§C.4.8.2.2	Procedure 2 Step 2
	2. Initiation action (register not serviced)	§C.4.8.2.2	Procedure 2 Step 1
	3. Initiation action (maximum number of contracts)	§C.4.8.2.2	Procedure 2 Step 2
	4. Initiation action (contract terminated)	§C.4.8.2.3	Procedure 3 Step 1
	5. Initiation action (all contracts terminated)	§C.4.8.2.6	Procedure 6 Step 7
	6. Initiation action (contract establishment failed)	§C.4.8.2.3	Procedure 3 Step 2
	7. Initiation action (EC field error)	§C.4.8.2.6	Procedure 6 Step 8
	8. Delivery failure notice	§C.4.8.2.3	Procedure 3 Step 3
	9. Non-interrogation timeout	§C.4.8.2.3	Procedure 3 Step 4
§C.4.7.3	Service provision	§C.4.8.2.8	Procedure 8 Step 3
§C.4.7.4	Downlink message structure		implicitly tested
§C.4.7.4.1	Contract report field.	§C.4.8.2.2	Procedure 2 Steps 1,2,3

Requirement Paragraph No	Headline	Test Chapter Paragraph No	Related test
§C.4.7.4.2	Unassigned bits		implicitly tested
§C.4.7.4.3	Contract information field -a. CI = 0	§C.4.8.2.5	Procedure 5 Step 2
	-b. CI = 1	§C.4.8.2.2	Procedure 2 Step 2
	-c. CI = 2	§C.4.8.2.2	Procedure 2 Step 1
	-d. CI = 3	§C.4.8.2.2	Procedure 2 Step 2
	-e. CI = 4	§C.4.8.2.2	Procedure 3 Step 1
	-f. CI = 5	§C.4.8.2.6	Procedure 6 Step 7
	-g. CI = 6	§C.4.8.2.8	Procedure 8 Step 3
	-h. CI = 7	§C.4.8.2.3	Procedure 3 Step 2
	-i. CI = 8-14		implicitly tested
	-j. CI = 15	§C.4.8.2.6	Procedure 6 Step 9
§C.4.7.4.3.1	Response type	§C.4.8.2.2	Procedure 2 Step 2
§C.4.7.5	Data Extraction by Mode S Ground stations		Implicitly tested
Table C-4-2	Dataflash for Register Monitoring service		implicitly tested

C.4.8 Test Procedures for Dataflash Application

C.4.8.1 Test Equipment

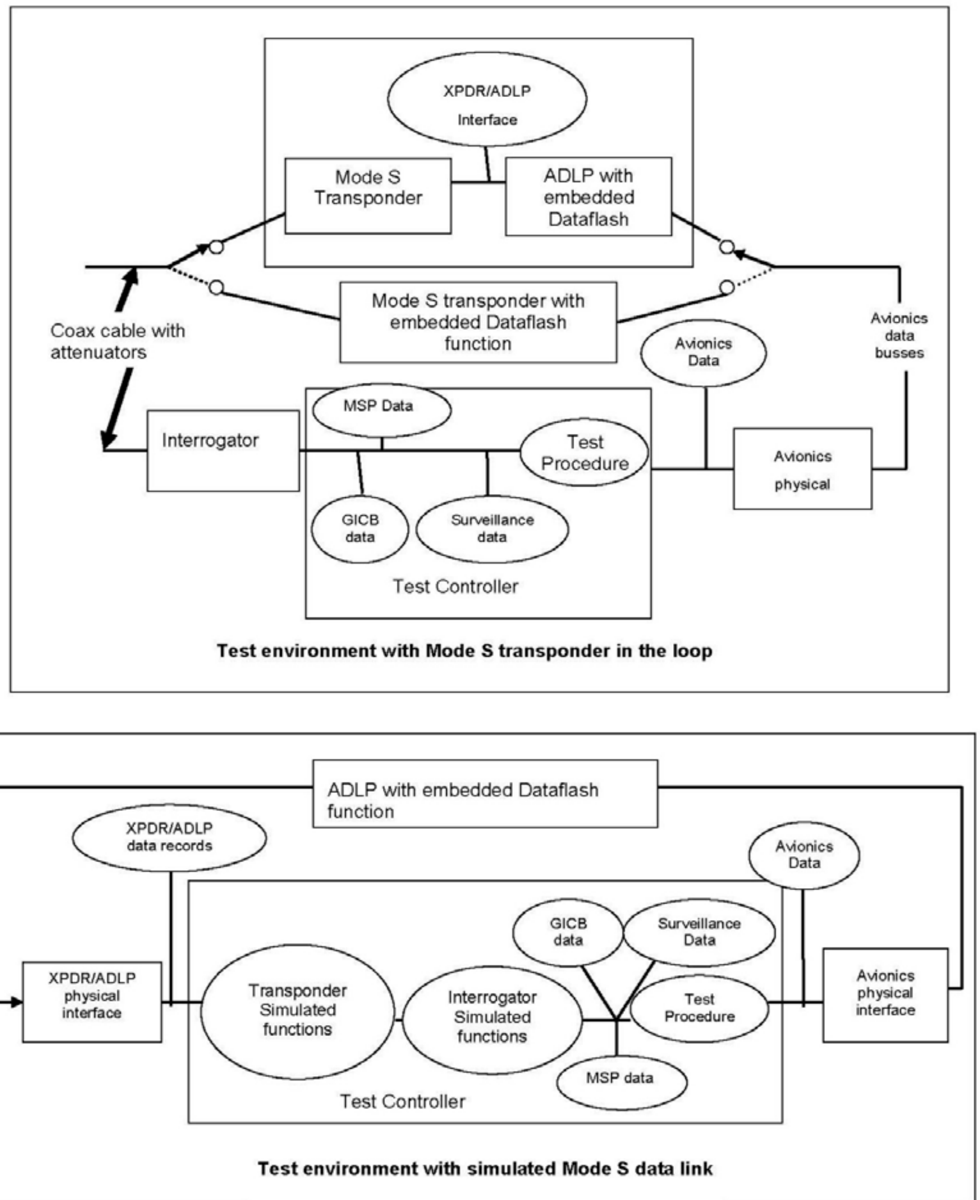
a. A Mode S transponder and a means to input and record test data into the Mode S transponder registers from simulated aircraft data buses at the required rates. (This may be done via an ADLP if the transponder does not have the Dataflash application inside it).

b. A means to interrogate the Mode S transponder at a regular rate between 6 and 10 seconds with surveillance interrogations and decode the replies.

c. A means to send data to the transponder, extract air initiated messages announced by the transponder, and extract the data from the transponder registers of the transponder, by means of interrogations with the appropriate control codes set.

d. A means to set up, record, and monitor Dataflash contracts by interrogating the Mode S transponder. Also a means of extracting and recording the data from the transponder when announced in the reply to a background surveillance interrogation.

The test equipment and its configuration will be dependent on where the Dataflash function resides. There are several possibilities, two examples of which are, either in an ADLP separate from a transponder, or in a combined ADLP transponder unit such as a Mark 4 transponder. The manufacturer **shall** declare the monitoring points to be used and offer a test equipment configuration to meet the requirements of the tests. Two possible test equipment configurations are shown in Figure C-4-1.



<u>Figure C-4-1:</u> Two Possible Test Equipment Options for Testing the Dataflash Application

C.4.8.2 Test Procedures

C.4.8.2.1 Procedure #1: Initialization and Checking for Dataflash Support

(Reference: §C.4.6.1)

This test procedure **shall** be carried out at the start of each test sequence to verify that the airborne Mode S system is functioning correctly and can support uplink MSP channel 6, downlink MSP channel 3, and the appropriate transponder registers.

Step 1 – MSPs installed and require service

a. Switch on the Mode S system under test and the test equipment and set the test interrogation II code to a non-zero value.

b. Start a regular pattern (one interrogation every 6 to 10 seconds) of Mode S Surveillance interrogations as shown in Table C-4-4.

Table C-4-4: Surveillance Interrogation

UF = 4 or 5	PC = 0	RR = 0	DI = 7	SD						AP
				IIS	RRS = 0		LOS = 0		TMS = 0	

c. Check that the specified replies are received and decoded correctly.

d. Extract the data from a transponder register using an interrogation as in Table C-4-4, but setting the RR field to 17 and the RRS subfield to ZERO (0). (This is a request for the Data Link Capability Report.)

e. Verify in the MB field of the reply that bit 25 is set to ONE (1). (This indicates that MSP services are supported.)

f. Extract the data from a transponder register using an interrogation as in Table C-4-4, but setting the RR field to 17 and the RRS subfield to 13. (This is a request for one of the Mode S Specific Services MSP capability report registers.)

g. Check in the MB field of the reply that bit 6 is set to ONE (1) indicating that MSP Uplink Channel 6 is installed and requires service, and that bit 31 is set to ONE (1) indicating that Downlink Channel 3 is installed and requires service.

Step 2 – Transponder Register data sources installed

a. Extract the data from a transponder register using an interrogation as in Table C-4-4, but setting the RR field to 17 and the RRS subfield to 8. (This is a request for one of the Mode S Specific Services MSP capability report registers.)

b. Check in the MB field of the reply and record the bits that are set to a ONE indicating that a transponder register service is indicated as installed.

c. Repeat Step 2 four times incrementing the RRS subfield by 1 each time to give RRS values 9, 10, 11, and 12.

Step 3 – Transponder Register data loading

a. Load known data into all transponder registers, indicated as installed from Step 2 above, in the transponder that contain other than static data (i.e., GICB capability report register etc.) at the minimum rate specified in ICAO Document 9688.

b. Extract the data from each register and verify that the data is correct.

c. Cease loading data into the transponder registers.

d. After a delay of at least twice the required update rate extract the data from each register and verify that the data is ALL ZEROs.

C.4.8.2.2 Procedure #2: Requesting the setup of Dataflash Contracts

(Reference: §C.4.6.3, §C.4.6.4, §C.4.6.5.2, §C.4.6.5.3, §C.4.6.7.1, §C.4.7.2.(1), §C.4.7.2.(2), §C.4.7.2.(3), §C.4.7.4.1, §C.4.7.4.3 & §C.4.7.4.3.1)

This test procedure is to check that the Dataflash application will not set up a contract for a transponder register that is not being serviced and that a contract can be set up when the transponder register is being serviced. It also checks that the maximum number of contracts for which the system is declared to be capable of handling can be set up. It also tests the function of CR field, the RDS field, and CI field values 1, 2, and 3.

Step 1 – Dataflash contract request for transponder registers not being loaded with data

a. Ensure that no data is being loaded into the installed transponder registers.

b. Send a Mode S uplink frame to the transponder containing an MSP packet as shown in Table C-4-5, on uplink MSP channel 6 with the BDS1 and BDS2 codes of the transponder register with which the contract is intended set into the DH field.

Table C-4-5: MSP Packet on MSP Channel 6

SR =1	DH					MT = 0	EC = 1	ST = 0
	CNS = 0	RDS = 1	Spare	BDS1	BDS2			

Note: *Mode S Frames are specified and tested in EUROCAE document ED-82.*

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder 0.1 seconds after the uplink frame in “b” above was received by the transponder.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-6 and it contains a DH equal to the value in the request interrogation and a value of 2 in the CI field. (This indicates that the contract was not accepted). Also verify that the CR field contains ALL ZEROs. (This indicates that there are no Dataflash contracts in existence.)

Note: *Since RDS = 1 in the contract request this test also verifies that the message register content is not sent when the register is not being loaded with data.*

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 1 requesting a contract for all transponder registers indicated as installed in the results of Procedure 1 Step 2.

Step 2 – Contract establishment for transponder registers being loaded with data

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder register.

b. Send a Mode S uplink frame to the transponder as specified in Table C-4-5 but with RDS=0, containing an MSP packet on uplink MSP channel 6.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7 and that it contains a DH equal to the value in the request interrogation. Verify that the CI field is set to ONE (1) when the contract is accepted, and that CI = 3 and the MSP packet is as shown in Table C-4-7, when the maximum number of contracts is exceeded. (This indicates that the contents of the transponder register are made available when the contract is established even though RDS=0). Also verify that in the CR field, the bit relating to the II code in the requesting interrogation is set to a ONE (1) for all II codes for which contracts have been accepted. (This indicates the contracts that have been accepted and are active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change the data in the transponder register so that the criterion for a Dataflash message to be triggered is met.

g. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the data changed.

h. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-6. Verify that it contains a DH equal to the value in the request interrogation in Step 2 “b”. Verify that the CI field is set to ZERO (0). (This indicates that after the contract has been established the transponder register data is not made available because RDS=0 in the contract request.)

Table C-4-6: MSP Packet on Downlink MSP Channel 3

DH (16 bits)	CR (15 bits)	Not Assigned (5 bits)	CI (4 bits)

i. Repeat Step 2 “b” to “c” but setting RDS=1 in Step 2 “b”.

j. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and that it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to ONE (1) when the contract is accepted and CI = 3 when the maximum number of contracts is exceeded. Also verify that in the CR field, the bit relating to the II code in the requesting interrogation is set to a ONE (1) for all II codes for which contracts have been accepted. (This indicates the contracts that have been accepted and are active.) Verify that the register message content is that which was loaded into the register specified in the contract request.

Table C-4-7: MSP Packet on Downlink MSP Channel 3

DH (16 bits)	CR (15 bits)	Not Assigned (5 bits)	CI (4 bits)	Register message content (56 bits)

k. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

l. Change the data in the transponder register so that the criterion for a Dataflash message to be triggered is met.

m. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 second after the data changed.

n. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7. Verify that it contains a DH equal to the value in the request interrogation in Step 2 “b”. Verify that the CI field is set to ZERO (0). (This indicates that after the contract has been established the transponder register data is made available because RDS=1 in the contract request.)

o. Repeat Procedure 2 Step 2 “a” to “e”, using a different non-zero II code each time requesting contracts up to a value equal to the maximum number of contracts that the system is declared to be capable of handling plus one. Use other transponder registers indicated as “installed” in the results of Procedure 1 Step 2 if the maximum number of contracts is more than 16.

p. Record the maximum number of contracts accepted, and verify that the number is at least 16, and that it is the maximum number declared by the manufacturer for the unit under test.

q. Use the techniques in §C.4.8.2.3 Procedure 3 to terminate all the contracts.

Step 3 – Multiple contract requests contained in a single MSP Packet on MSP channel 6

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder register.

b. Depending on the transponder Level, send a Mode S uplink frame to the transponder containing an MSP packet as shown in Table C-4-8 or Table C-4-9 with RDS=1 in the Dataflash Header(DH), on uplink MSP channel 6 with different BDS codes of transponder registers being loaded in a above for each contract request.

Table C-4-8: MSP Packet Containing Multiple Contract Requests for a Level 2 Transponder

	Contract 1				Contract 2						END
SR=1	DH	MT	EC=1	ST	DH	MT	EC=4	ST	CQ Quanta	CT Threshold	DH=0

This will result in an Uplink 4 Segment Linked Comm A frame.

Table C-4-9: MSP Packet Containing Multiple Contract Requests for Level 3 and above Transponders

	Contract 1				Contract 2					Contract 3						END	Fill data
SR=1	DH	MT	EC=1	ST	DH	MT	EC=2	ST	CQ Quanta	DH	MT	EC=4	ST	CQ Quanta	CT Threshold	DH=0	All ZEROs

This will result in an Uplink ELM frame

c. Verify that downlink transactions directed to the II code that was used in the requesting transaction in “b” above, are announced by the transponder in replies to surveillance interrogations sent to the transponder, the first one, no later than 0.1 seconds after the uplink frame in “b” above was sent and one for each subsequent contract request as soon as the previous transaction has been closed out.

d. Extract each downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and that it contains DH equal to the value in the contract request interrogation, and verify that the CI field is set to ONE (1) and the relevant bit of the CR field is set to ONE (1) indicating the same II code as was set in the interrogation requesting transaction in “b” above. (This indicates that the contract was accepted and is active.)

e. Verify that all the requested contracts have been accepted.

f. Closeout each downlink transaction by means of a surveillance interrogation to the transponder.

g. Use the techniques in §C.4.8.2.3 Procedure 3 to terminate all the contracts.

Step 4 – Tests of wrong values in the Service Request (SR) header in MSP packet on uplink MSP channel 6

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet as in Table C-4-5, on uplink MSP channel 6, but with the SR field set to ZERO (0).

c. Verify that no downlink transaction is announced by the transponder in the reply to a surveillance interrogation as in Table C-4-4, sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent. (No downlink response indicates that the contract was not accepted.)

d. Repeat Step 1 requesting the same contract using all other SR values. i.e., 2 to 255 inclusive and verify that no Dataflash downlink transactions are announced by the transponder.

C.4.8.2.3 Procedure #3: Termination of Dataflash Contracts

(Reference: §C.4.6.7.1, §C.4.7.2.(4), §C.4.7.2.(6), §C.4.7.2.(8), §C.4.7.2.(9), & §C.4.7.4.3)

This Procedure tests the different methods of terminating Dataflash contracts and can be performed in conjunction with Procedure 2 of §C.4.8.2.2 in order to minimize the total number of tests required.

Step 1 – Dataflash contract termination by the interrogator using the EC Field

a. Establish the maximum number of contracts as in Procedure 2 §C.4.8.2.2.

b. For an established contract send a Mode S uplink Frame containing an MSP packet as in Table C-4-5, on uplink MSP channel 6, but with the EC Field set to ZERO (0). (This should cause the contract to be cancelled.)

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after each uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet as shown in Table C-4-7, on Downlink MSP channel 3 and it contains a DH field corresponding to the contract to be cancelled and that the CI field is set to a value of 4. (This indicates that the contract has been cancelled.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 1 for all the established contracts.

Step 2 – Dataflash contract termination by transponder register losing its source data

a. Establish the maximum number of contracts as in Procedure 2 Step 2 sections “a” to “e” in §C.4.8.2.2.

b. For an established contract discontinue the loading of the relevant transponder register. (This should cause the contract to be cancelled.)

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation shown in Table C-4-4, sent to the transponder no later than 0.1 seconds after each uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH field corresponding to the contract for the transponder register which is no longer serviced and that the CI field is set to a value of 7. (This indicates that the contract has been cancelled.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 1 for all the established contracts.

Step 3 – Dataflash contract termination by the airborne application due to link failure

a. Establish a contract as in Procedure 2 Step 2 sections “a” to “e,” in §C.4.8.2.2.

b. Change and record the data pattern being loaded into the relevant transponder register.

c. Verify that a downlink transaction is announced by the transponder, directed to the II code that was used in the requesting transaction, in the reply to a surveillance interrogation shown in Table C-4-4, sent to the transponder no later than 0.1 seconds after the data change in “b” above.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH field equal to that in the request interrogation, and verify that the CI field is set to ZERO. (This indicates that the contract has detected the change in data and is functioning correctly.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change and record the data pattern being loaded into the relevant transponder register.

g. Verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation no later than 1 second after the data change in “f” above.

h. Wait 35 seconds.

i. Verify that a downlink transaction is no longer announced in replies to surveillance interrogations. (This indicates that the airborne system has declared a link failure and should have terminated the contract).

j. Change the data pattern being loaded into the relevant transponder register and record the new pattern.

Verify that NO downlink transaction is announced by the transponder in the reply to surveillance interrogations after the data change in “j” above. (This means that the contract has been cancelled by the airborne system.)

Step 4 – Dataflash contract termination due to loss of service from an interrogator with the same II code as the one that initiated the contract

a. Establish a contract as in Procedure 2 Step 2 sections “a” to “e,” in §C.4.8.2.2.

b. Change and record the data pattern being loaded into the relevant transponder register.

c. Verify that a downlink transaction is announced by the transponder, directed to the II code that was used in the requesting transaction, in the reply to a surveillance interrogation shown in Table C-4-4, sent to the transponder no later than 0.1 seconds after the data change in “b” above.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH field equal to that in the request interrogation, and verify that the CI field is set to ZERO. (This indicates that the contract has detected the change in data and is functioning correctly.)

e. Change the II code of all interrogations to the transponder, record the new II code, and repeat “a” to “d” above. Verify in the CR field of the response in “d” above, that contracts are indicated for both the original and the new II codes.

f. Wait 60 seconds from the time of the last interrogation with the original II code and repeat “b” to “d” above. Verify in the response to “d” above that the CR field indicates no contracts for the original II code. (This confirms that the contracts to the original II code have been cancelled.)

g. Repeat the whole of Step 4 “a” to “f” to test all II codes as the original II code.

C.4.8.2.4 Procedure #4: Dataflash Header (DH) Field Tests

(Reference: §C.4.6.5.1)

This Procedure tests for the correct interpretation of the Contract Number Subfield (CNS) in the DH field. The BDS code subfield interpretation is tested in §C.4.8.2.2 Procedure #2 Step 2.

Step 1 – Establishing multiple contracts with a single transponder register

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder registers.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-5, with the BDS1 and BDS2 codes set for a contract with a selected transponder register.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 1 “a” to “e” using the same BDS1 and BDS2 codes in the interrogations in “c” above, and setting each of the other values in the CNS subfield in turn in “b” above.

g. Repeat Step 1 “a” to “f” for at least three different transponder registers.

Note: *If in “f” or “g” above the maximum number of contracts that the transponder can handle is reached, the contracts must be terminated by the method used in Procedure 3 Step 1 in §C.4.8.2.3 above, and this test continued to test all CNS values.*

h. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

C.4.8.2.5 Procedure #5: Minimum Time (MT) Field Tests

(Reference: §C.4.6.6 & §C.4.7.4.3)

This Procedure tests for the correct interpretation of the Minimum Time (MT) field contained in the MSP packet of uplink MSP channel 6.

Step 1 – Data changing at longer intervals than the value in the MT field

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder registers.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-5.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change the transponder register data being loaded into the transponder register which was indicated in the contract initiated in “a” to “d” above.

g. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the transponder register data was changed in the transponder register.

h. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1).

i. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 1 “f.” Verify that it contains the new changed data that was loaded into that transponder register. (This indicates that the changed data is immediately available as requested in the MT field.)

j. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

k. Repeat Step 1 “f” to “j” at least 10 times and verify that all the data changes are reported.

l. Repeat Step 1 “f” to “k” for values of 10, 50, 100, 150, and 255 seconds set into the MT field of the MSP packet in “b” above, and the transponder register data changes of “f” above, at rates of 11, 51, 101, 151, and 256 seconds respectively.

m. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 2 – Data changing at shorter intervals than the value in the MT field

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder registers.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-5.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change the contract by sending a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-5, but with the MT field set to ONE (1) second.

g. Change data being loaded into the transponder register at time intervals approximately equal to a quarter of the time indicated in the MT field of the requesting contract.

h. Verify that a downlink transaction is NOT announced by the transponder in the reply to a surveillance interrogation sent to the transponder at any time earlier than the value in MT field.

i. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than the value in the MT field plus 0.1 seconds after the previous data extraction.

j. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to ZERO (0). (This indicates a response to an existing contract.)

k. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 2 “f” above. Verify that it contains the latest data that was loaded into that transponder register before expiry of the time value in the MT field. (This indicates that the MT field is being interpreted correctly.)

l. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

m. Repeat Step 1 “f” to “l” with MT values of 10, 50, 100, 150, 200, and 255 seconds being set into the MSP packet on MSP uplink channel 6 of “f” above.

n. Terminate the contract by the method used in §C.4.8.2.3 Procedure 3 Step 1.

C.4.8.2.6 Procedure #6: Event Criterion (EC) Field Tests

(Reference: §C.4.6.7.1, §C.4.6.8, §C.4.7.2.(5), §C.4.7.2.(7), & §C.7.4.3)

This Procedure tests the 4 bit Event Criterion Field (EC. Tests for the EC values of ZERO (0) and ONE (1) are covered in the previous Procedures. CI field values 0, 1, 3, and 5, and CR field bit tests are included in this Procedure.

Step 1 – Tests with EC Field = 2

a. Ensure that data is being loaded into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-10 with BDS1 and BDS2 codes to set up a contract with the register being loaded in “a” above, and the bits in the Change Quanta (CQ) field set to alternating Zeros and Ones, starting with a ZERO (0).

Table C-4-10: MSP Packet on MSP Channel 6 with EC=2

SR=1	DH					MT=0	EC=2	ST=0	CQ Quanta (56 bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2				

Note: *When EC=2 the Change Quanta (CQ) field is interpreted as 56 individual bits. When a bit is set to ZERO, the corresponding bit in the transponder register is not monitored and when it is set to a ONE a report is sent whenever the corresponding bit in the transponder register changes.*

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each bit in the transponder register in turn, change that bit and perform “g,” “h,” “i,” “j,” and “k” below.

g. When the corresponding bit in the CQ Quanta is set to a ONE verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “f” above was sent.

h. When the corresponding bit in the CQ Quanta is set to a ZERO (0) verify that NO downlink transaction is announced by the transponder in the reply to a surveillance interrogation.

i. Extract all announced downlink transactions, and verify that they are MSP Packets on Downlink MSP channel 3 as in Table C-4-7, and they contain a DH equal to the value in the request interrogation and the CI field is set to a value of ZERO.

j. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 1 “b” above. Verify that it contains the data that was loaded into that transponder register. (This indicates that the change monitoring is functioning correctly.)

k. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

l. Repeat the whole of Step 1 for all of the transponder registers capable of being serviced.

m. For at least three of the transponder registers set the bits in the CQ Quanta to alternating Ones and Zeros, starting with a ONE (1) in the first bit and repeat Step 1.

n. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 2 – LSB change tests with EC Field = 3

a. Ensure that data is being loaded into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-11 with BDS1 and BDS2 codes to set up a contract with the register being loaded in "a" above. Also set the sub divided fields in the Change Quanta field (CQ) as in (i) and (ii) below:

(i) When the sub divided field represents a numerical value set it to the least significant bit value.

(ii) When the sub field represents a character or status information set it to ALL ONEs.

Table C-4-11: MSP Packet on MSP Channel 6 with EC=3

SR=1	DH					MT=0	EC=3	ST=0	CQ Quanta (56 bits) LSB=1 all other bits = 0
	CNS=0	RDS = 1	Spare	BDS1	BDS2				

Note: *When EC=3 the Change Quanta field (CQ) is sub-divided into the same fields as the transponder register with which the contract is being made. For each of these sub-divided fields ALL ZEROs indicates that changes to that parameter are not to be reported and ALL ONEs indicates that any change to that parameter **shall** be reported. Otherwise the value in the subfield for a parameter **shall** be the decimal value of the quantum of the minimum change in that parameter, taking any sign bit into account, which has to be reported. The units of the change parameter are the same as the least significant bit of the parameter being monitored. Status and switch bits are treated as separate fields for change field monitoring.*

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each parameter in the transponder register in turn, change the parameter by an amount equal to its least significant bit.

g. Verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in f. above was sent.

h. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ZERO (0).

i. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 2 "b" above. Verify that it contains the data that was loaded into that transponder register. (This indicates that the change monitoring is functioning correctly.)

j. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

k. Repeat "f" to "j," this time changing each parameter in turn by an amount equal to its most significant bit.

l. Repeat the whole of Step 2 for all of the transponder registers capable of being serviced.

m. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 3 – MSB change tests with EC Field = 3

a. Ensure that data is being loaded into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-11 with BDS1 and BDS2 codes to set up a contract with the register being loaded in "a" above. Also set the sub divided fields in the Change Quanta field (CQ) as in (i) and (ii) below:

    (i) When the sub divided field represents a numerical value set it to the least significant bit value.

    (ii) When the sub field represents a character or status information set it to ALL ONEs.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each parameter in the transponder register in turn, change the parameter by an amount equal to its most significant bit.

g. Verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the parameter change in “f” above was sent.

h. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ZERO (0).

i. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 3 “b” above. Verify that it contains the data that was loaded into that transponder register. (This indicates that the change monitoring is functioning correctly.)

j. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

k. For each parameter in the transponder register in turn, change the parameter by an amount equal to less than its most significant bit.

l. Verify that NO downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder after the parameter change in “i” above was sent. (This indicates that the contract is functioning correctly.)

m. Repeat the whole of Step 3 for all of the transponder registers capable of being serviced.

n. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 4 – Tests with EC Field = 4 (Only report changes above a threshold value)

a. Ensure that data having a value of the least significant bit is being loaded, into all the fields that represent numerical values, into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-12 with BDS1 and BDS2 codes to set up a contract with the register being loaded in “a” above. Set the sub fields in the Change Quanta (CQ) field to a value equal to a maximum of one quarter of the MSB, or to the LSB, in each case where the field represents a numerical value. Set the CQ field to ALL ONEs where the field represents a character or status information etc. Also set a Threshold value equal to the MSB for all fields that represent a numerical value in the CT Threshold.

Table C-4-12: MSP Packet on MSP Channel 6 with EC=4

SR=1	DH					MT=0	EC=4	STS=0	CQ Quanta (56 bits)	CT Threshold (56 Bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2					

Note: *When EC=4 the Change Threshold (CT) field is sub-divided into the same subfields as the transponder register with which the contract is being made. For each of these sub-divided fields ALL ZEROs indicates that changes to that parameter are not to be reported. Otherwise the value in the subfield for a parameter **shall** be the decimal value of the threshold for that parameter taking any sign bit into account. Only parameter changes that cross the threshold criterion are reported. The Change Quanta (CQ) field is similarly divided into subfields which indicate that a change will not be reported for that subfield until the parameter has changed by at least the CQ value since the contract was agreed in the case of a first report, or since the last report generated by this contract.*

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each parameter in the transponder register in turn, increment the parameter value every time a surveillance interrogation is sent to the transponder, in steps equal to the value that has been specified for it in the CQ Quanta until the threshold has been crossed by at least four increments, or has reached its maximum value, and perform the actions of “g,” “h,” “i,” and “j” below.

Note: *The reason for crossing the threshold by four increments if possible is to verify that all changes greater that CQ that are above the threshold crossing are reported.*

g. Extract any announced downlink transaction and verify that they are MSP Packets on Downlink MSP channel 3 as in Table C-4-7, and they contain a DH equal to the value in the request interrogation and the CI field is set to a value of ZERO (0).

h. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 4 “b” above. Verify that it contains the data that was loaded into that transponder register and that the data is equal to or has exceeded the value set in the threshold for the parameter under test. (This indicates that the change monitoring is functioning correctly.)

i. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

j. Verify that a correct downlink transaction was only received for each parameter increment that gave a value higher than the threshold.

k. Repeat the whole of Step 4 for all of the transponder registers capable of being serviced.

l. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 5 – Tests with EC Field = 5 (Only report changes below a threshold value)

a. Ensure that data having the maximum value is being loaded into all the fields that represent numerical values, into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-13, with BDS1 and BDS2 codes to set up a contract with the register being loaded in "a" above, and the subfields in the Change Quanta (CQ) field set to the least significant bit value in each case where the subfield represents a numerical value, and to ALL ONEs where the field represents a character or status information etc. Set a Threshold value equal to the MSB for all fields that represent a numerical value in the CT Threshold.

Table C-4-13: MSP Packet on MSP Channel 6 with EC=5

SR=1	DH					MT=0	EC=5	STS=0	CQ Quanta (56 bits)	CT Threshold (56 Bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2					

Note: *When EC=5 the Change Threshold field (CT) is divided into the same subfields as the transponder register with which the contract is being made. For each of these subfields ALL ZEROs indicates that changes to that parameter are not to be reported. Otherwise the value in the subfield for a parameter **shall** be the decimal value of the threshold for that parameter taking any sign bit into account. Only changes in the parameter that are equal to or greater than the CQ Quanta value and are lower than the threshold are reported.*

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each parameter in the transponder register in turn, decrement the parameter value every time a surveillance interrogation is sent to the transponder, in steps equal to the value that has been specified in the Dataflash contact request in Step 5 “b” above for it in the CQ Quanta until the threshold has been crossed by at least four decrements, or has reached its minimum value, and perform the actions of “g,” “h,” “i,” and “j” below.

g. Extract any announced downlink transactions and verify that they are MSP Packets on Downlink MSP channel 3 as in Table C-4-7, and they contain a DH equal to the value in the request interrogation.

h. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 5 “b” above. Verify that it contains the data that was loaded into that transponder register and that the data is equal to or has gone below the value set in the threshold for the parameter under test. (This indicates that the change monitoring is functioning correctly.)

i. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

j. Verify that a correct downlink transaction was only received for each parameter increment that gave a value lower than the threshold.

k. Repeat the whole of Step 5 for all of the transponder registers capable of being serviced.

l. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 6 – Tests with EC Field = 6 (Only report changes when the threshold is crossed)

a. Ensure that data having a value of at least 4 Quanta below the threshold or the minimum for the parameter, is being loaded into all the fields that represent numerical values, into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-14, with BDS1 and BDS2 codes to set up a contract with the register being loaded in “a” above, and the sub divided fields in the Change Quanta (CQ) field set to the least significant bit value in each case where the field represents a numerical value, and to ALL ONEs where the field represents a character or status information etc. Set a Threshold value equal to the MSB for all fields that represent a numerical value in the CT Threshold.

Table C-4-14: MSP Packet on MSP Channel 6 with EC=6

SR=1	DH					MT=0	EC=6	ST=0	CQ Quanta (56 bits)	CT Threshold (56 Bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2					

Note: *When EC=6 the Change Threshold field (CT) is sub-divided into the same fields as the transponder register with which the contract is being made. For each of these sub-divided fields ALL ZEROs indicates that changes to that parameter are not to be reported. Otherwise the value in the subfield for a parameter* ***shall*** *be the decimal value of the threshold for that parameter taking any sign bit into account. Only changes in the parameter that are equal to or greater than the CQ Quanta value and cross the threshold in either direction are reported.*

c. Verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. For each parameter in the transponder register in turn, increment the parameter value every time a surveillance interrogation is sent to the transponder, in steps equal to the value that has been specified in the Dataflash contract request in Step 6 “b” above (in the CQ Quanta) until a downlink transaction is announced in the reply to a surveillance interrogation then perform tests “g,” “h,” “i,” and “j” below.

g. Extract any announced downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ZERO (0).

h. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 1 “b” above. Verify that it contains the data that was loaded into that transponder register and that the data has crossed the value set in the threshold for the parameter under test. (This indicates that the change monitoring is functioning correctly.)

i. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

j. Verify that only one downlink transaction was announced and extracted and that it contained the data value for the first increment after the threshold was crossed. (This indicates that the threshold is functioning correctly.)

k. Ensure that data having a value of at least 4 Quanta above the threshold, or the maximum value for the parameter, is being loaded into all the fields that represent numerical values, into one of the installed transponder registers and record the data being loaded into the transponder register.

l. Repeat the whole of Step 6 but decrementing the parameter value in "f" above.

m. Repeat the whole of Step 6 for all of the transponder registers capable of being serviced.

n. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

Step 7 – Single II CodeTests with EC Field = 15 (Cancel all contracts for the II Code in this request regardless of other information in the DH Field)

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder registers.

b. Send a Mode S uplink frame using II code = 1 to the transponder, containing an MSP packet on uplink MSP channel 6 as in Table C-4-5, with the BDS1 and BDS2 codes set for a contract with a selected transponder register.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to a value of ONE (1), and the bit in the CR field corresponding to the II code used in "b" above is set to a ONE (1). (This indicates that the new contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 7 "a" to "e" using different BDS1 and BDS2 codes corresponding to registers that are being loaded with data in the interrogations in "b" above until the maximum number of contracts that can be handled by the system under test have been established. If the maximum number of contracts that can be handled exceeds the number of transponder registers being loaded then repeat "a" to "e" above, setting different values in the CNS subfield in the uplink frames in "b" above until the maximum number of contracts is reached.

g. Send a Mode S uplink frame using II code set as in "b" above, to the transponder, containing an MSP packet on uplink MSP channel 6 as in Table C-4-5, with the BDS1 and BDS2 codes set for a contract with a selected transponder register with the EC field set to a value of 15.

h. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “g” above was sent.

i. Extract the downlink transaction and close it out by means of a surveillance interrogation sent to the transponder. Verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and that it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to 5. (This indicates that all contracts for the II code set in the interrogation at “g” above have been cancelled).

j. Change the data being loaded into the transponder registers that have contracts established such that a Dataflash message would be triggered if a contract currently existed.

k. Verify that no downlink transactions are announced in the replies to surveillance interrogations in the following 30 seconds.

l. Repeat Step “a” to “i” For II codes 2 to 14 inclusive.

Step 8 – Multiple II CodeTests with EC Field = 15 (Cancel all contracts for the II Code in this request regardless of other information in the DH Field

a. Ensure that data is being loaded into the installed transponder registers and record the data being loaded into each transponder registers.

b. Send a Mode S uplink frame using II code = 1 to the transponder, containing an MSP packet on uplink MSP channel 6 as in Table C-4-5, with the BDS1 and BDS2 codes set for a contract with a selected transponder register.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “b” above was sent.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to a value of ONE (1) and the bit in the CR field corresponding to the II code used in “b” above is set to a value of ONE (1). (This indicates that the contract was accepted and is active.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 8 “a” to “e” incrementing the II code in the interrogation in “b” above until the maximum number of contracts that can be handled by the system under test have been established. If the maximum number of contracts that can be handled exceeds the number of II codes repeat “a” to “e” above accessing different transponder registers by setting different values the BDS1 and BDS2 subfields in the uplink frames in “b” above until the maximum number of contracts is reached.

g. Send a Mode S uplink frame setting the II code to the same value as in “b” above, to the transponder, containing an MSP packet on uplink MSP channel 6 as shown in Table C-4-5, with the BDS1 and BDS2 codes set for a contract with a transponder register not contracted for that II code and with the EC field set to a value of 15.

h. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction in “g” above, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in “g” above was sent.

i. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7 and that it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to 5 and the bit in the CR field corresponding to the II code used in “b” above is set to a ZERO (0). (This indicates that all contracts for the II code set in the interrogation at “g” above have been cancelled).

j. Change the data being loaded into the transponder registers that have contracts established such that a Dataflash message would be triggered if a contract currently existed.

k. Verify that a separate downlink transaction is announced, directed to each II code other than the II code that was used in “b” above, is announced by the transponder in the replies to a surveillance interrogations sent to the transponder in the period after the uplink frame in “g” above was sent. Also verify that no transaction is announced directed to the II code used in “b” above.

l. Extract each downlink transaction and close it out by means of a surveillance interrogation sent to the transponder. Verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and that it contains a DH equal to the value in the request interrogation. Also verify that the CI field is set to 01 and the bit in the CR field corresponding to the II code used in “b” above is set to a ONE (1). (This indicates that all contracts other than those for the II code set in the interrogation at “g” are still in existence and working normally).

m. Repeat Step 8 “a” to “l” using II codes 2 to 14 inclusive in “b” above.

Step 9 – Tests with EC Field set to unassigned values

a. Ensure that data is being loaded into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-15 with BDS1 and BDS2 codes to set up a contract with the register being loaded in “a” above and EC set to 7.

Table C-4-15: MSP Packet on MSP Channel 6

SR=1	DH					MT=0	EC	ST=0	CF Quanta (56 bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2				

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of 15. (This indicates that the contract was NOT accepted. This is the correct result because the EC is not valid.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat the whole of Step 9 "a" to "e" incrementing the EC by ONE until EC=14.

C.4.8.2.7 Procedure #7: Stable Time (ST) Field tests

(Reference: §C.4.6.7.2)

This Procedure tests the correct functioning of the ST field.

Step 1 – Tests with ST Field

a. Ensure that fixed data is being loaded into one of the installed transponder registers and record the data being loaded into the transponder register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet on uplink MSP channel 6 as in Table C-4-16 with BDS1 and BDS2 codes to set up a contract with the register being loaded in "a" and ST set to ONE (1).

Table C-4-16: MSP Packet on MSP Channel 6 with EC=2

SR=1	DH					MT=0	EC=2	ST	CQ Quanta (56 bits)
	CNS=0	RDS = 1	Spare	BDS1	BDS2				

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder no later than 0.1 seconds after the uplink frame in "b" above was sent.

d. Extract the downlink transaction and verify that it is an MSP Packet on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to a value of ONE (1). (This indicates that the new contract was accepted and is active.)

e. Use an interrogation as in Table C-4-4 but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 1 “b” above, and with EC = 2. Verify that it contains the data that was loaded into that transponder register for the parameter under test.

f. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

g. Change and record the data being loaded into any parameter of the transponder register by an amount that exceeds the Quanta value specified in the contract, at intervals equal to one quarter of the value in ST.

h. Verify that NO downlink transaction is announced by the transponder in the reply to surveillance interrogations whilst the data is changing as in “g” above.

i. Stop changing the data being loaded into the transponder register and record the register data.

j. Verify that a downlink transaction is announced by the transponder in the reply to a surveillance interrogation sent to the transponder not earlier than a time equal to ST, and no later than time equal to the value of ST plus 0.1 seconds after the data was first changed.

k. Extract all announced downlink transactions and verify that they contain MSP Packets on Downlink MSP channel 3 as in Table C-4-7, and it contains a DH equal to the value in the request interrogation and the CI field is set to ZERO (0).

l. Use an interrogation as in Table C-4-4, but with the RR field and RRS subfield set to extract the GICB that was specified in the Dataflash request in Step 1 “b” above. Verify that it contains the same data that was loaded into that transponder register at “i” above. (This indicates that ST is functioning correctly.)

m. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

n. Repeat the “f” to “l” above, for each parameter in the transponder register.

o. Repeat the “a” to “l” above setting values of ST = 2, 4, 8, 12, and 15 seconds in “b” above.

p. Repeat the whole of Step 1 using at least three different transponder registers.

q. Terminate all contracts by the method used in §C.4.8.2.3 Procedure 3 Step 1.

C.4.8.2.8 Procedure #8: Maximum Message Rate

(Reference: §C.4.7.3, & §C.4.7.4.3)

This Procedure tests that no more than ten Dataflash messages are output in any six seconds period and that waiting messages are queued and announced to the ground with an indication of delay by setting CI = 6 in the response, as soon as the maximum message criterion allows.

Step 1 – Initializing contracts

a. Ensure that NO data is loaded into any of the transponder registers.

b. Send a Mode S uplink frame to the transponder containing an MSP packet as shown in Table C-4-5, on uplink MSP channel 6. With the BDS1 and BDS2 codes of the transponder register with which the contract is intended set into the DH field.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder 0.1 seconds after the uplink frame in "b" above was received by the transponder.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and it contains a DH equal to the value in the request interrogation and a value of 2 in the CI field. (This indicates that the new contract was not accepted.) Also verify that the CR field contains ALL ZEROs. (This indicates that there are no Dataflash contracts in existence.)

Note: *Since RDS=1 in the contract request this test also verifies that the message register content is not sent when CI is not equal to ZERO.*

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Repeat Step 1 requesting a contract for at least two transponder registers

Step 2 – Dataflash Message triggering rate up to six messages per second

a. Ensure that fixed data is being loaded into the installed registers and being updated at a rate faster than the minimum rate specified for each register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet as shown in Table C-4-5, on uplink MSP channel 6. With the BDS1 and BDS2 codes of the transponder register with which the contract is intended set into the DH field.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder 0.1 seconds after the uplink frame in "b" above was received by the transponder.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and it contains a DH equal to the value in the request interrogation and a value of ONE (1) in the CI field. (This indicates that the new contract was accepted.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change the data in one or more of the registers in order to trigger ten Dataflash messages every six seconds.

g. Verify that downlink transactions, directed to the II code that was used in the requesting transaction, are announced by the transponder in the reply to a surveillance interrogations sent to the transponder 0.1 seconds after the each of the data changes in “e” above were received by the transponder.

h. Extract and closeout the downlink transactions and verify that they are MSP packets on Downlink MSP channel 3 as shown in Table C-4-7, and they contain a DH equal to the value in the request interrogation and a value of ZERO (0) in the CI field. (This indicates that they are responses to an existing contract.)

Note: *Closeout each downlink transaction by means of a surveillance interrogation to the transponder.*

Step 3 – Dataflash Message triggering rate greater than six messages per second

a. Ensure that fixed data is being loaded into the installed registers and being updated at a rate faster than the minimum rate specified for each register.

b. Send a Mode S uplink frame to the transponder containing an MSP packet as shown in Table C-4-5, on uplink MSP channel 6 with the BDS1 and BDS2 codes of the transponder register with which the contract is intended set into the DH field.

c. Verify that a downlink transaction, directed to the II code that was used in the requesting transaction, is announced by the transponder in the reply to a surveillance interrogation sent to the transponder 0.1 seconds after the uplink frame in “b” above was received by the transponder.

d. Extract the downlink transaction and verify that it is an MSP packet on Downlink MSP channel 3 as shown in Table C-4-7, and it contains a DH equal to the value in the request interrogation and a value of ONE (1) in the CI field. (This indicates that the new contract was accepted.)

e. Closeout the downlink transaction by means of a surveillance interrogation to the transponder.

f. Change the data in one or more of the registers in order to trigger more than ten Dataflash messages every six seconds for a period of at least twelve seconds.

g. Verify that downlink transactions, directed to the II code that was used in the requesting transaction are announced by the transponder in the replies to surveillance interrogations sent to the transponder starting 0.1 seconds after the first of the data changes in “f” above were received by the transponder.

h. Extract and closeout all the downlink transactions and verify that they are MSP packets on Downlink MSP channel 3 as shown in Table C-4-7. Verify that they contain a DH equal to the value in the request interrogation and do not exceed a rate of ten messages in any six seconds period. Verify that messages, which are not delayed due to the Dataflash message limit of ten within six seconds, contain a value of ZERO (0) in the CI field. (This indicates that they are normal responses to an existing contract.) Also verify that Dataflash messages which have been delayed by queuing in order to remain within the limit for Dataflash messages contain a value of 6 in the CI field. (This indicates that the responses to an existing contract which have been delayed due to Dataflash message limit queuing.)

Note: *Closeout each downlink transaction by means of a surveillance interrogation to the transponder.*

C.4.8.2.9 Procedure #9: Test of Mode S Subnetwork Version Number and Global Capability Reporting

Extract Register 10_{16}

Verify that:

- Bit 17 - 23 = 3 (for an Annex 10 Amendment 77 transponder), = 4 (for an Annex 10 Amendment 81 and Doc 9871 Edition 1 transponder), > 4 (for future Amendments of Annex 10 and future editions of Doc 9871)
- Bit 25 =1

Inject all data used to fill register 40_{16}, 50_{16} and 60_{16}

Reset the transponder (in order to take into account dynamic check at start-up)

Extract Register 17_{16}

Verify that:

- Bit 9 = 1
- Bit 16 = 1
- Bit 24 = 1

Extract Register $1D_{16}$

Verify that:

- Bit 6 = 0 and Bit 31 = 0 if no dataflash application supported
- Bit 6 = 1 and Bit 31 = 1 if dataflash application is supported

Extract Register 19_{16}

Verify that:

- Bit 49 = 1
- Bit 33 = 1
- Bit 17 = 1

Stop injection of all data with the aircraft data generator

Extract register 17_{16}

Verify that:

- Bit 9 = 0
- Bit 16 = 0
- Bit 24 = 0

Extract register 19_{16}

Verify that:

- Bit 49 = 1
- Bit 33 = 1
- Bit 17 = 1

C.4.9 Dataflash Installed System Performance

Installed performance **shall** be consistent with that specified in §C.4.8, which was verified through bench and environmental tests. However, certain performance parameters may be affected by the physical installation and can only be verified after installation. The installed performance specified below takes this into consideration.

C.4.9.1 Ground Test Procedures

a. Conformity Inspection

(1) Visually inspect the installed equipment or system to determine the use of acceptable workmanship and engineering practices.

(2) Verify that proper mechanical and electrical connections have been made and that the equipment or system has been located and installed in accordance with the manufacturer's recommendations.

b. Test Equipment Required

(1) A means to interrogate the Mode S transponder with surveillance interrogations and decode the resulting replies.

(2) A means to send data to the transponder registers, extract the air initiated messages announced by the transponder, and extract the data from the

registers in the transponder accessed by means of the BDS1 and BDS2 codes in interrogations sent to the transponder.

(3) A means to set up, record and monitor Dataflash contracts by interrogating the Mode S transponder.

c. Test Procedure

(1) Input data either directly from aircraft data sources or stimulate the aircraft systems, such that all the declared transponder registers are being updated.

(2) Using the test equipment, extract the appropriate capability reports and verify that the aircraft Mode S system is functioning, and that it can support uplink MSP channel 6, Downlink MSP channel 3, and the appropriate transponder registers are being updated by the aircraft systems.

d. Interference Effects

With the equipment or system energized,

(1) individually operate each of the other electrically operated aircraft equipment and systems to determine that no significant interference effects are present:

(2) evaluate all reasonable combinations of control settings and operating modes.

C.4.10 Implementation Guidelines for Dataflash

C.4.10.1 Overview

Dataflash is a service which announces the availability of information from air-to-ground on an event-triggered basis. This is an efficient means of downlinking information which changes occasionally and unpredictably.

A contract is sent to the airborne application through the Mode S transponder and the ADLP using an uplink Mode S specific protocol (MSP) (MSP 6, SR = 1) as specified in ICAO Doc 9871, Appendix A. This uplink MSP packet contains information specifying the events which should be monitored regarding the changes of data in a transponder register. When the event occurs, this is announced to the ground installation using the AICB protocol.

The ground installation may then request the downlink information which takes the form of a downlink MSP packet on channel 3 constituted of one or two linked Comm-B segments. The second segment is a direct copy of the relevant transponder register specified in the contract.

The ground system with the embedded dataflash application should determine if an aircraft supports the dataflash protocol as follows:

- if bit 25 of transponder register 10_{16} is set to 1, the system will extract transponder register $1D_{16}$, then,

- if bit 6 and bit 31 of transponder register $1D_{16}$ are set to 1, then the aircraft supports the dataflash service.

C.4.10.2 Minimum number of contracts

The minimum number of contracts activated simultaneously that can be supported by the airborne installation should be at least 64. In the case of a software upgrade of existing installations, at least 16 dataflash contracts should be supported.

C.4.10.3 Contract request for a transponder register not serviced by the airborne installation

On the receipt of a dataflash service request, a downlink dataflash message should immediately be announced to the ground regardless of any event criteria. This message is used by the ground system to confirm that the service has been initiated. The message will only consist of one segment. In the case of a service request for an unavailable transponder register, the message sent to the ground should only contain bits 1 to 40 of the downlink message structure with a CI field value of 2. This value will indicate to the ground system that the service request cannot be honored because of the unavailability of the transponder register. The service will then be terminated by the airborne dataflash function, and the ground system should notify the user which has initiated the request that the service request cannot be honored by the airborne installation.

When a transponder register (which was previously supported) becomes unavailable and is currently monitored by a dataflash contract, a downlink dataflash message containing bits 1 to 40 will be sent with a CI field value of 7. This will indicate to the ground that the transponder register is not serviced anymore. The related contract is terminated by the airborne application, and the ground system should notify the user which has initiated the request that the service request has been terminated by the airborne installation. An alternative means for the ground system to detect that the transponder register is not serviced any longer is to analyze the resulting transponder register 10_{16} which will be broadcast by the transponder to indicate to the ground system that transponder register 17_{16} has changed. The Mode S sensor should then extract transponder register 17_{16} and send it to the ground application. The ground application should then analyze the content of this transponder register and should notice that the transponder register monitored by a dataflash contract is no longer supported by the airborne installation.

C.4.10.4 Service continuity in overlapping coverage with radars using the same II code

Depending on the system configuration the following guidance should be taken into account to ensure service continuity in overlapping coverage of radars working with the same II code.

C.4.10.4.1 Radar with the dataflash application embedded in the radar software

For this configuration it is necessary to manage the contract numbers which will be used by each station and to ensure that the same contract number for the same transponder register is not used by another sensor having overlapping coverage and working with the same II code. The reason for this is that a sensor has no means of detecting if a contract it has initialized has been overwritten by another sensor using an identical dataflash header. Also one sensor could terminate a contract because an aircraft is leaving its coverage and no other sensor would know that this contract had been closed. For this reason, no dataflash contract termination should be attempted by either sensor in order to ensure a service continuity.

When two ground stations with overlapping coverage and having the same II code each set up dataflash contracts with the same transponder register for the same aircraft, it is essential to ensure that the contract number is checked by each ground station prior to the closeout of any AICB which is announcing a dataflash message.

C.4.10.4.2 Use of an ATC centre-based dataflash application

The ATC system hosting the dataflash application should manage the distribution of contract numbers for sensors operating with the same II code. This ATC system will also have the global view of the aircraft path within the ATC coverage to either initiate or close dataflash contracts when appropriate. This is the preferred configuration since a central management of the contract numbers is possible which also allows a clean termination of the contracts.

C.4.10.5 Ground management of multiple contracts for the same transponder register

The ground system managing the dataflash application must ensure that when it receives a request from ground applications for several contracts to monitor different parameters, or different threshold criteria, related to the same transponder register for a particular aircraft/II code pair, it assigns a unique contract number for each contract sent to the aircraft.

C.4.10.6 Service termination

There are three ways to terminate a dataflash service (one from the ground initiative, two from the airborne installation):

1. The ground can send an MSP with the ECS field set to 0 which means that the service is to be discontinued by the airborne installation.

2. The airborne installation will terminate the service with no indication to the ground system if any message is not extracted from the transponder by a ground interrogator within 30 seconds following the event specified in the dataflash contract (TZ timer).

3. When the transponder has not been selectively interrogated by a Mode S interrogator with a particular II code for 60 seconds (this is determined by monitoring the IIS subfield in all accepted Mode S interrogations), all dataflash contracts related to that II code will be cancelled with no indication to the ground system.

The termination from the ground initiative is the preferable way to terminate the service since both the ground and the airborne systems terminate the service thanks to a mutually understood data link exchange. This termination should nevertheless not be allowed in certain configurations especially with adjacent sensors (with the dataflash application embedded in the sensor software) working with the same II code as explained in §C.2.1. If the termination of the contract by a ground system is to be exercised, it should also be noticed that the ground system should anticipate the exit of the aircraft from its coverage to send the close-out message.

C.4.10.7 Dataflash request containing multiple contracts

It is possible to merge several contracts into one single dataflash request. If multiple events occur which are related to several contracts of the initial dataflash request, one downlink message for each individual event should be triggered containing the associated transponder register. Each of these downlink messages should use the air initiated protocol.

C.4.10.8 Transponder register data contained in the downlink message

The transponder register data received by the ground system following the extraction of a downlink dataflash message consisting of two segments are the transponder register data at the time of the event. The transponder register data may be up to 1 aerial scan old since the event may occur just after the illumination of the aircraft. Should the end-user need more up-to-date data, the user should use the event announcement to trigger extraction via GICB protocol to get the latest transponder register data.

Appendix D

For the Potential Addition
of
Hijack Mode Operations

FORWARD

This Appendix is being presented in order to assist the implementor who may be interested in providing the capabilities that were originally outlined in Change 1 to RTCA/DO-181C for the addition of Hijack Mode Operations to a Mode S transponder.

The actual content of Change 1 to RTCA/DO-181C is being provided here with all references updated to reflect the possibility of using this Appendix with RTCA DO-181E.

This Appendix offers a potential change to DO-181D with revisions of text for:

Section §2.1 – General Requirements for All Equipment,

- Replace Section §2.1.7, Flight Crew Control Functions
- Add Section §2.1.10.1, Antenna/Transponder Configurations

Section §2.2 – Minimum Performance Standards – Standard Conditions and Signals,

- Add Section §2.2.27, "Mode S Transponder Hijack Mode"

Section §2.5.4 – Test Procedures,

- Add Section §2.5.4.40, "Procedure #40 Mode S Transponder Hijack Mode (§2.2.27)"

Appropriate paragraphs of Section §3 – Installed Equipment Performance.

- Replace Section §3.1.2 – Inadvertent Turn Off
- Add Section §3.1 revisions:

  - Add Paragraph §3.1.4.1. – Normal Equipment Operations,
  - Add Paragraph §3.1.4.2 – Hijack Mode Equipment Operations,
  - Add Paragraph §3.1.8 – Single Operational Transponder at One Time,

  - Add Paragraph §3.3.16 – Single Operational Transponder at One Time, and
  - Add Paragraph §3.3.17 – Hijack Mode Operations

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D. For the Potential Addition of Hijack Mode Operations

2.1.7 Flight Crew Control Functions

The following functions **shall** be provided.

a. Means of selecting each of the ATCRBS 4096 Identity Codes and of indicating the code selected.

(1). If the Hijack Mode (§2.2.27) is activated by means that do not involve the Control Function, then the "7500" Hijack Code **shall NOT** be displayed by the Control Function.

Note: *An example of a means that does not involve the Control Function would be an input discrete connected to a switch.*

b. ATCRBS, ATCRBS/Mode S All Call, and Mode S-only All Call Interrogations

(1). Non-Hijack Mode (§2.2.27):

Means of selecting the condition in which the transponder is rendered incapable of generating replies to ATCRBS, ATCRBS/Mode S All Call, and Mode S-only All Call interrogations, but continues to generate Mode S squitter transmissions and continues to reply to discretely addressed Mode-S interrogations when the aircraft is on the ground (§2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b and §2.2.18.2.7.c) and **NOT** in the Hijack Mode (§2.2.27). Return to normal operation from this condition **shall** be possible within five seconds. If this condition is enabled automatically when the aircraft is on the ground, a flight crew switch is not necessary. If performed manually, this condition **shall** have no effect on the transmission of extended squitters (§2.2.23.1.2) or on the reporting of on-the-ground state (§2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b, and §2.2.18.2.7.c).

Transponders that simulate ATCRBS/MODE S All Call interrogations in self-test/squitter transmission may occasionally open their window of non-acceptance for this purpose coincidental with an actual interrogation, thus generating a reply to the interrogations. Such coincidental acceptance periods may be considered tolerable, but must not exceed one percent of transponder operating time.

(2). Hijack Mode (§2.2.27):

No method **shall** be capable of rendering the transponder incapable of generating replies to ATCRBS and Mode-S Only All-Call interrogations whenever the transponder is in the Hijack Mode (§2.2.27) whether in the airborne or in the on-ground state (§2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b and §2.2.18.2.7.c). The transponder **shall** also continue to generate Mode S squitter transmissions and reply to discretely addressed Mode-S interrogations when the aircraft is in the Hijack Mode (§2.2.27).

c. Standby Selection:

(1). Non-Hijack Mode (§2.2.27):

Means of selecting the condition in which all transponder functions, other than transmissions on the reply frequency and associated self-testing, are operational (i.e., the Standby condition) when **NOT** in the Hijack Mode (§2.2.27). Return to normal operation from this condition **shall** be possible within five seconds.

(2). Hijack Mode (§2.2.27):

No method **shall** be capable of placing the transponder into the Standby Mode once the transponder has entered the Hijack Mode (§2.2.27) except as specified in §2.2.27.5.2.

d. Means of initiating the IDENT (SPI) feature.

e. Inhibiting Altitude Reporting:

(1). Non-Hijack Mode (§2.2.27):

Means of inhibiting the transmissions of altitude information, while retaining the ATCRBS framing pulses in ATCRBS Mode C replies and while transmitting all ZERO's in the altitude field of Mode S replies when **NOT** in the Hijack Mode (§2.2.27).

(2). Hijack Mode (§2.2.27):

No method **shall** be capable of placing the transponder in a mode that inhibits the transmission of altitude information when in the Hijack Mode (§2.2.27) and in the airborne state (§2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b and §2.2.18.2.7.c) except as specified in §2.2.27.2.1.1.b.

f. If the aircraft uses a flight number for aircraft identification, a means **shall** be provided for the variable aircraft identification to be inserted by the pilot.

2.1.10.1 Antenna / Transponder Configurations

When implementing the Hijack Mode (§2.2.27), a means **shall** be provided to distinguish to the transponder that the installation is primarily configured either as described in §2.1.10.1.a or as described in §2.1.10.1.b.

Note: *Such means may be provided by the use of different transponder part numbers, program pins, installation setup or configuration menus, or other acceptable means.*

a. Dual Antenna Systems and Dual Diversity Transponders

The installation is configured with an independent set of antennas (e.g., top and bottom) for each diversity transponder.

While in the Hijack Mode (§2.2.27), a Dual Antenna System and Dual Diversity Transponder configuration must operate in a manner that insures that only one system is radiating from the aircraft at a given time.

Note: *In order to do so, the Dual Antenna System and Dual Diversity Transponder configuration requires that the transponders operate in accordance with Section §2.2.27.1.1.1, §2.2.27.1.2.1, or §2.2.27.1.3.1.*

b. Single Antenna System and Dual Diversity Transponders

The installation is configured with a single set of antennas (e.g., top and bottom) that is switched between two diversity transponders.

While in the Hijack Mode (§2.2.27) a Single Antenna System and Dual Diversity Transponders configuration **shall** operate in a manner that insures that only one transponder is coupled to the radiating antenna system at a given time.

Note: *In order to do so, the Single Antenna System and Dual Diversity Transponder configuration requires that the transponders operate in accordance with Section §2.2.27.1.1.2, §2.2.27.1.2.2, or §2.2.27.1.3.2.*

c. Other Configurations

(1). Dual Antenna Systems and Dual Non-Diversity Transponders

The installation is configured with an independent bottom antenna for each transponder.

In terms of indicating Antenna / Transponder configuration to the transponder, this configuration **shall** be considered to be the same as the Dual Antenna Systems and Dual Diversity Transponder configuration identified in subparagraph §2.1.10.1.a.

(2). Single Antenna and Dual Non-Diversity Transponders

The installation is configured with a single bottom antenna that is switched between two transponders.

In terms of indicating Antenna / Transponder configuration to the transponder, this configuration **shall** be considered to be the same as the Single Antenna System and Dual Diversity Transponder configuration identified in subparagraph §2.1.10.1.b.

(3). All Other Antenna / Transponder Configurations

In terms of indicating Antenna / Transponder configuration to the transponder, all other configurations that are not consistent with §2.1.10.1.a, §2.1.10.1.b, §2.1.10.1.c.(1), or §2.1.10.1.c.(2) **shall** be considered to be the same as the Single Antenna System and Dual Diversity Transponder configuration identified in subparagraph §2.1.10.1.b.

Note: *The single antenna system and single diversity transponder is included in this configuration type.*

2.2.27 Mode S Transponder Hijack Mode

Note: *The following requirements address the implementation of the Hijack Mode via the Mode-S Transponder upon being commanded to enter the mode via Flight Crew Control functions (§2.1.7) or discrete inputs as identified in the subsequent paragraphs. The following requirements* ***DO NOT*** *preclude implementation of the Hijack Mode function within existing transponder system installations using appropriate control components or functions which are fully external to the transponder unit itself.*

2.2.27.1 Hijack Mode Entry Procedures

Note 1: *The term "Active On", introduced in the following subparagraphs, refers to the state where the transponder is not in the Hijack Mode nor the Standby state. Refer to Section §2.1.7.c, which specifies the Standby state and thereby implies the Normal state, which is equivalent to the Active On state.*

Note 2: *The terms "Active Hijack" mode and "Standby Hijack" mode, introduced in the following subparagraphs, refers to two different modes of operation as described below. The term "Hijack Mode" is a generic term and refers to both the Active Hijack Mode and the Standby Hijack Mode of the transponder.*

2.2.27.1.1 Standard "7500" Code Entry

Upon continuous receipt (or selection) of 4096 Identity Code **"7500"** (see §2.1.7.a and §2.2.13.1.2.b) for a minimum period of 10 seconds, transponders **shall** operate depending upon the intended configuration and the initial state of the unit as follows:

Note: *The period of 10 seconds applies to "as seen by the transponder." Any additional latency that is applied by the control function that is providing the "7500" code must be taken into consideration at the installed system level.*

2.2.27.1.1.1 Dual Antenna Systems and Dual Diversity Transponder Configuration

Transponders intended for Dual Antenna Systems and Dual Diversity Transponder configuration (see §2.1.10.1.a) **shall** operate as follows:

a. The Active On transponder **shall** enter the Active Hijack Mode.

b. The Standby transponder **shall** enter the Standby Hijack Mode

2.2.27.1.1.2 Single Antenna System and Dual Diversity Transponder Configuration

Transponders intended for Single Antenna System and Dual Diversity Transponder configurations (see §2.1.10.1.b) **shall** operate as follows:

a. The Active On transponder **shall** enter the Active Hijack Mode.

b. The Standby transponder **shall** enter the Active Hijack Mode.

Note: *For Single Antenna Set – Dual Diversity Transponder Configurations a means should be provided to ensure that the Standby transponder will not cause adverse emission effects on-board the aircraft. This may be implemented by having the transponder "check" if there is an antenna actually connected* *before transmitting in the Active Hijack Mode or ensuring that the standby transponder antenna ports are properly terminated.*

2.2.27.1.2 "7500" Code Entry with SPI

Upon receipt (or selection) of 4096 Identity Code "7500" (see §2.1.7.a and §2.2.13.1.2.b) and activation of the Special Position Identifier (SPI, Ident.) (see §2.1.7.d and §2.2.13.1.2.d) being coincident in any order, transponders **shall** operate depending upon the intended configuration and the initial state of the unit as follows:

Note: *The requirement is written with any coincidence or order between the "7500" Identity Code and the SPI since some controls immediately send the 4096 Identity Code upon activation of the SPI. Other controls may add latency to the code entry but not the SPI. Still other installations may implement a separate SPI activation such as a remotely activated discrete that is not a direct function of the Control Panel.*

2.2.27.1.2.1 Dual Antenna Systems and Dual Diversity Transponder Configuration

Transponders intended for Dual Antenna Systems and Dual Diversity Transponder configurations (see §2.1.10.1.a) **shall** operate as follows:

a. The Active On transponder **shall** immediately enter the Active Hijack Mode.

b. The Standby transponder **shall** immediately enter the Standby Hijack Mode

2.2.27.1.2.2 Single Antenna System and Dual Diversity Transponder Configuration

Transponders intended for Single Antenna System and Dual Diversity Transponder configurations (see §2.1.10.1.b) **shall** operate as follows:

a. The Active On transponder **shall** immediately enter the Active Hijack Mode.

b. The Standby transponder **shall** immediately enter the Active Hijack Mode.

2.2.27.1.3 Hijack Mode Discrete Initialization

a. The transponder **shall** provide for a discrete input to allow Hijack mode activation.

b. De-bounce time necessary to verify that the discrete was properly activated **shall NOT** exceed 1.0 seconds.

c. Upon detection of the discrete input, transponders **shall** operate depending upon the intended configuration and the initial state of the unit as follows:

2.2.27.1.3.1 Dual Antenna Systems and Dual Diversity Transponder Configuration

Transponders intended for Dual Antenna Systems and Dual Diversity Transponder configurations (see §2.1.10.1.a) **shall** operate as follows:

a. The Active On transponder **shall** immediately enter the Active Hijack Mode.

b. The Standby transponder **shall** immediately enter the Standby Hijack Mode.

2.2.27.1.3.2 Single Antenna System and Dual Diversity Transponder Configuration

Transponders intended for Single Antenna System and Dual Diversity Transponder configurations (see §2.1.10.1.b) **shall** operate as follows:

a. The Active On transponder **shall** immediately enter the Active Hijack Mode.

b. The Standby transponder **shall** immediately enter the Active Hijack Mode.

2.2.27.2 Active Hijack Mode Operations

Note: *Special consideration for installed equipment configurations are addressed in Section §3.0, "Installed Equipment Performance."*

2.2.27.2.1 General Requirements (Airborne and On-Ground states)

Upon entry of the Active Hijack Mode, both an Airborne unit and an On-Ground unit **shall**:

a. Enter 4096 Identity Code "7500" into all Mode-A ATCRBS (see §2.2.13.1.2.b and §2.2.4.1.2) replies and into the ID (see §2.2.14.4.16) field of DF=5, DF=21 Mode-S replies.

b. Set the SPI (see §2.2.4.1.3) active in all Mode-A ATCRBS replies for a period of 18 ±1 seconds.

c. Accept no further transponder control information.

Note: *The typical Control functions implemented for the transponder include but are not limited to Standby/On selection, Altitude Reporting selection, SPI initiation, 4096 Identity Code selection, Altitude Data Source selection, Transponder "1/2" selection, and Functional Test activation.*

d. Remain in Active Hijack Mode until the Hijack Mode Exit procedure is performed (see subparagraph §2.2.27.5 and specifically §2.2.27.5.2).

e. Establish the Alert Condition in accordance with Section §2.2.18.2.7.

f. Establish the Flight Status, "FS", field in accordance with Section §2.2.14.4.14.

g. Continue to emit squitter transmissions.

2.2.27.2.1.1 Altitude Reporting Requirements

a. Valid Altitude Information Available:

When in the Active Hijack Mode both an Airborne transponder and an On Ground transponder **shall** continually provide the transmission of valid altitude information (see §2.1.7.e.(2)) in all replies to interrogations required by §2.1.7.b and §2.1.7.e regardless of flight crew or other commands that may attempt to inhibit the reporting of altitude data.

b. Invalid Altitude Information:

When in the Active Hijack Mode, invalid altitude information **shall** result in both an Airborne transponder and an On Ground transponder continuing to:

(1). Provide ATCRBS Mode C replies with ATCRBS Framing Pulses only

(2). Provide Mode S replies with all ZERO's in the altitude field

2.2.27.2.1.2 TCAS Communication Requirements (if TCAS equipped)

When in the Active Hijack mode, the transponder **shall** continue to support all TCAS operations as required with the following exceptions:

a. The transponder **shall** set the Sensitivity Level Control sent to the on-board TCAS to a maximum capability of "TA Only" mode. The following constraints **shall** apply:

(1). If the Sensitivity Level Control (SLC) received by the transponder from its associated Control function is set to indicate a mode that is less than the "TA/RA" mode (i.e., SL=1 or 2) then the same SLC **shall** be provided to the on-board TCAS.

(2). If the Sensitivity Level Control received from the Control function is set to TA/RA mode, then it **shall** be changed to TA Only (i.e., SL=2) prior to the transponder providing it to the on-board TCAS.

Note 1: *ARINC-735A, Attachment 6D provides the following definition for Manual Sensitivity Level Control via the ARINC-429 Label "016" TCAS, Mode-S, and TA/RA Display control word.*

Manual Sensitivity Level Control			
BITS			
17	***16***	***15***	***MEANING***
0	*0*	*0*	*SL = 0 (AUTOMATIC)*
0	*0*	*1*	*SL = 1 (STANDBY)*
0	*1*	*0*	*SL = 2 (TA ONLY)*
0	*1*	*1*	*SL = 3*
1	*0*	*0*	*SL = 4*
1	*0*	*1*	*SL = 5*
1	*1*	*0*	*SL = 6*
1	*1*	*1*	*SL = 7*

Note 2: *SL = 0 may not be used by all control functions.*

b. The transponder **shall** set the 4096 Identity Code sent to the on-board TCAS to the code of "7500" at all times while in the Active Hijack Mode.

Note: *This action should be performed, as it may be advantageous in the future to advise the on-board TCAS that the transponder system is set to the Hijack mode.*

2.2.27.2.2 On-Ground State Only

The transponder **shall** continue to operate in accordance with §2.1.7.b when in the Active Hijack Mode and in the On-Ground state (§2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b and §2.2.18.2.7.c).

2.2.27.2.3 Loss of Control

Once in the Active Hijack Mode, the transponder **shall** ensure that it remains in the Active Hijack mode even if all communication is lost with the Control function.

Specifically, the transponder **shall NOT** enter the Active On, Standby or Standby Hijack modes upon determining that it is no longer receiving control information.

Note: *TCAS System installations require that the transponder pass control information to the TCAS Computer "AS RECEIVED." Loss of control information to the transponder will result in loss of control information to the TCAS Computer, which in turn may result in a "TCAS System Fail" indication to the operator.*

2.2.27.3 Standby Hijack Mode Operations

2.2.27.3.1 General Requirements (Airborne and On-Ground states)

Upon entry of the Standby Hijack Mode, both an Airborne unit and a unit on the Ground **shall**:

a. Accept no further transponder control information.

Note: *The typical Control functions implemented for the transponder include but are not limited to Standby/On selection, Altitude Reporting selection, SPI initiation, 4096 Identity Code selection, Altitude Data Source selection, Transponder "1/2" selection, and Functional Test activation.*

b. **NOT** reply to ATCRBS interrogations.

c. **NOT** reply to Mode S interrogations.

d. **NOT** emit squitter transmissions.

e. Remain in Standby Hijack Mode until the Hijack Mode Exit procedure is performed (see subparagraph §2.2.27.5 and specifically §2.2.27.5.2). Specifically, the transponder **shall NOT** be capable of exiting the Standby Hijack Mode and entering the Active Hijack or the Active ON Mode.

2.2.27.3.2 TCAS Communication Requirements (if TCAS equipped)

When in the Standby Hijack mode, the transponder **shall** continue to support all TCAS operations as required with the following exceptions:

a. The transponder **shall** set the Sensitivity Level Control sent to the on-board TCAS to a maximum capability of TA Only mode. The following constraints **shall** apply:

(1). If the Sensitivity Level Control (SLC) received by the transponder from its associated Control function is set to indicate a mode that is less than the TA/RA mode (i.e., SL=1 or 2) then the same SLC **shall** be provided to the on-board TCAS.

(2). If the Sensitivity Level Control received from the Control function is set to TA/RA mode, then it **shall** be changed to TA Only (i.e., SL=2) prior to the transponder providing it to the on-board TCAS.

Note 1: *ARINC-735A, Attachment 6D provides the following definition for Manual Sensitivity Level Control via the ARINC-429 Label "016" TCAS, Mode-S, and TA/RA Display control word.*

Manual Sensitivity Level Control			
BITS			
17	***16***	***15***	***MEANING***
0	*0*	*0*	*SL = 0 (AUTOMATIC)*
0	*0*	*1*	*SL = 1 (STANDBY)*
0	*1*	*0*	*SL = 2 (TA ONLY)*
0	*1*	*1*	*SL = 3*
1	*0*	*0*	*SL = 4*
1	*0*	*1*	*SL = 5*
1	*1*	*0*	*SL = 6*
1	*1*	*1*	*SL = 7*

Note 2: *SL = 0 may not be used by all control functions.*

b. The transponder **shall** set the 4096 Identity Code sent to the on-board TCAS to the code of "7500" at all times while in the Standby Hijack Mode.

Note: *This action should be performed, as it may be advantageous in the future to advise the on-board TCAS that the transponder system is set to the Hijack mode.*

2.2.27.3.3 Loss of Control

Once in the Standby Hijack Mode, the transponder **shall** ensure that it remains in the Standby Hijack mode even if all communication is lost with the Control function. Specifically, the transponder **shall NOT** enter the Standby, Active On, or Active Hijack modes upon determining that it is no longer receiving control information.

Note: *TCAS System installations require that the transponder pass control information to the TCAS Computer "AS RECEIVED." Loss of control information to the transponder will result in loss of control information to the TCAS Computer, which in turn may result in a "TCAS System Fail" indication to the operator.*

2.2.27.4 Hijack Mode Indication

a. A means **shall** be provided to indicate that the transponder is in the Active Hijack Mode.

b. A means **shall** be provided to indicate that the transponder is in the Standby Hijack Mode for transponders intended for installation in the Dual Antenna Systems and Dual Diversity Transponder configuration.

Note: *The Standby Hijack Mode indication is required to give some indication that the transponder is in that mode. Otherwise, it would be impossible to verify that the transponder exits the mode upon proper execution of the exit procedures.*

c. Momentary power interrupts **shall NOT** cause the indication described in subparagraph §2.2.27.4.a. to give a false indication that the Active Hijack Mode is active.

d. Momentary power interrupts **shall NOT** cause the indication described in subparagraph §2.2.27.4.b. to give a false indication that the Standby Hijack Mode is active.

Note: *The Hijack Mode Indication is specifically not intended for flight deck implementation. Some installations may not desire an indication of the Hijack Mode: however, the transponder must be capable of providing such capability if other installations or regulatory agencies should require such indication.*

2.2.27.5 Hijack Mode Exit Procedures

Note: *Refer to §2.2.13.1.2.c, §2.2.23.3.7, §2.2.18.2.7.b, and §2.2.18.2.7.c for determination of Airborne or On-Ground (i.e., Surface) state.*

2.2.27.5.1 Airborne State

Performance of Hijack Mode Exit Procedures (§2.2.27.5) while in the airborne state **shall** result in the transponder **NOT** exiting the Active Hijack Mode nor the Standby Hijack Mode.

2.2.27.5.2 On-Ground State

While in the On-Ground State, a means **shall** be provided that **shall** result in:

a. The Active Hijack Mode transponder exiting the Active Hijack mode.

b. The Standby Hijack transponder exiting the Standby Hijack Mode.

c. The following indications that the Hijack Mode Exit operation has successfully been accomplished.

   (1). Provide a satisfactory visual indication (e.g., illuminating the Functional Test Lamp) for a minimum period of 1 second.

   (2). Ensuring that the Active Hijack Mode Indication (§2.2.27.4.a) indicates that the Active Hijack Mode is **NOT** active.

   (3). Ensuring that the Standby Hijack Mode Indication (§2.2.27.4.b) indicates that the Standby Hijack Mode is **NOT** active.

2.2.27.6 Power Interrupt Conditions

If the Hijack Mode Exit procedure has not been performed as per §2.2.27.5.2, transponders that have the capability to retain last known state information prior to a Power Off condition (e.g., Non-Volatile Memory, etc.) **shall** provide the capability for the transponder to return to the Active Hijack Mode or Standby Hijack Mode upon restoration of power.

2.5.4.40 Procedure #40 Mode S Transponder Hijack Mode (§2.2.27)

Part 1 of this procedure verifies that the transponder intended for a Dual Antenna System and Dual Diversity Transponder Configuration properly executes all the Hijack Mode Entry requirements specified in §2.2.27 for the Mode S Transponder Hijack Mode.

Part 2 of this procedure verifies that the transponder intended for a Single Antenna System and Dual Diversity Transponder Configuration properly executes all the Hijack Mode Entry requirements specified in §2.2.27 for the Mode S Transponder Hijack Mode.

Parts 3 and 4 of this procedure tests the functions of the Hijack Modes and contains the actual tests which are common to both types of installation configuration. These tests are called out specifically in Parts 1 and 2 as needed.

Part 5 of this procedure tests the power interrupt operations of the Hijack Modes.

Note: *This entire procedure assumes that the transponder is configured such that the Air/Ground discrete inputs are being used to inhibit replies in accordance with §2.1.7.b.*

Part 1: Dual Antenna System and Dual Diversity Transponder Configuration

Note: *This procedure applies to the transponder in a Dual Antenna Systems and Dual Diversity Transponder configuration.*

a. Initial State = Active On

With the transponder being in the Active On and Airborne states and **NOT** in the Hijack Mode:

(1). Normal Non-Hijack Operation (initial test state)

Provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet. Ensure that the altitude reporting function of the transponder is **NOT** inhibited.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7777" and **NO** SPI Pulse.

(b). Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

(c). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(d). Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(e). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7777."

(f). Properly provides the on-board TCAS (if TCAS equipped) with an SLC=0 decimal via the Transponder/TCAS interface

(g). Properly provides the on-board TCAS (if TCAS equipped) with a 4096 Identity Code set to "7777."

(h). Is **NOT** indicating the Hijack mode.

(2). Standard "7500" Code Entry (§2.2.27.1.1, §2.2.27.1.1.1.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "0" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

(a). Approximately 10 seconds after providing the 4096 Identity Code of "7500", verify the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the Airborne tests as called out in Part 3.a.

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b. (5).

(c). Provide the transponder with a 4096 Identity Code of "7500."

Approximately 10 seconds after providing the 4096 Identity Code of "7500", verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the On-Ground tests as called out in Part 3.b.

(3). "7500" Code Entry with SPI (§2.2.27.1.2, §2.2.27.1.2.1.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "0" decimal. Provide the transponder with an altitude input of 8,000 feet. As soon as possible, thereafter, initiate the SPI (Ident) function.

(a). Immediately after providing the SPI function, verify the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Provide the transponder with a 4096 Identity Code of "7500." As soon as possible, thereafter, initiate the SPI (Ident) function.

Immediately after providing the SPI function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

(4). Hijack Mode Discrete Initialization (§2.2.27.1.3, §2.2.27.1.3.1.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal. Provide the transponder with an altitude input of 8,000 feet. Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

(a). Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

b. Initial State = Standby

With the transponder being in the Standby and Airborne states and **NOT** in the Hijack Mode:

(1). Normal Non-Hijack Operation (initial test state)

Provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "1" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to any of the interrogations.

(b). Does **NOT** emit squitter transmissions.

(c). Does **NOT** indicate that it **IS** in the Standby Hijack Mode.

(2). Standard "7500" Code Entry (§2.2.27.1.1, §2.2.27.1.1.1.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "1" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

(a). Approximately 10 seconds after providing the 4096 Identity Code of "7500", verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing all the Airborne tests as called out in Part 4.a.

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 4 of these test procedures and exit the Hijack Mode as called out in Part 4.b.(4).

(c). Provide the transponder with a 4096 Identity Code of "7500."

Approximately 10 seconds after providing the 4096 Identity Code of "7500," verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing all the On-Ground tests as called out in Part 4.b.

(3). "7500" Code Entry with SPI (§2.2.27.1.2, §2.2.27.1.2.1.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "1" decimal. Provide the transponder with an altitude input of 8,000 feet. As soon as possible, thereafter, initiate the SPI (Ident) function.

(a). Immediately after providing the SPI function, verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing the Airborne General Requirements tests as called out in Part 4.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 4 of these test procedures and exit the Hijack Mode as called out in Part 4.b.(4).

(c). Provide the transponder with a 4096 Identity Code of "7500." As soon as possible, thereafter, initiate the SPI (Ident) function.

Immediately after providing the SPI function, verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 4.b.(1).

(d). Exit the Hijack Mode as called out in Part 4.b.(4) of these test procedures.

(4). Hijack Mode Discrete Initialization (§2.2.27.1.3, §2.2.27.1.3.1.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "1" decimal. Provide the transponder with an altitude input of 8,000 feet. Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

(a). Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing the Airborne General Requirements tests as called out in Part 4.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 4 of these test procedures and exit the Hijack Mode as called out in Part 4.b.(4).

(c). Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Standby Hijack mode by proceeding to Part 4 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 4.b.(1).

(d). Exit the Hijack Mode as called out in Part 4.b.(4) of these test procedures.

Part 2: Single Antenna System and Dual Diversity Transponder Configuration

Note: *This procedure applies to the transponder in a Single Antenna System and Dual Diversity Transponder configuration.*

a. Initial State = Active On

With the transponder being in the Active On and Airborne states and **NOT** in the Hijack Mode:

(1). Normal Non-Hijack Operation (initial test state)

Provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet. Ensure that the altitude reporting function of the transponder is **NOT** inhibited.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7777” and **NO** SPI Pulse.

(b). Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

(c). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(d). Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(e). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7777.”

(f). Properly provides the on-board TCAS (if TCAS equipped) with an SLC=0 decimal via the Transponder/TCAS interface

(g). Properly provides the on-board TCAS (if TCAS equipped) with a 4096 Identity Code set to “7777.”

(h). Is **NOT** indicating the Hijack mode.

(2). Standard “7500” Code Entry (§2.2.27.1.1, §2.2.27.1.1.2.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of “7500” and a Sensitivity Level Control (SLC) of “0” decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

(a). Approximately 10 seconds after providing the 4096 Identity Code of “7500”, verify the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the Airborne tests as called out in Part 3.a.

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Provide the transponder with a 4096 Identity Code of “7500.”

Approximately 10 seconds after providing the 4096 Identity Code of “7500”, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the On-Ground tests as called out in Part 3.b.

(3). “7500” Code Entry with SPI (§2.2.27.1.2, §2.2.27.1.2.2.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of “7500” and a Sensitivity Level Control (SLC) of “0” decimal. Provide the transponder with an altitude input of 8,000 feet. As soon as possible, thereafter, initiate the SPI (Ident) function.

(a). Immediately after providing the SPI function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Provide the transponder with a 4096 Identity Code of "7500." As soon as possible, thereafter, initiate the SPI (Ident) function.

Immediately after providing the SPI function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

(4). Hijack Mode Discrete Initialization (§2.2.27.1.3, §2.2.27.1.3.2.a)

With the transponder in the Active On and Airborne states, provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal. Provide the transponder with an altitude input of 8,000 feet. Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

(a). Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

b. Initial State = Standby

With the transponder being in the Standby and Airborne states and **NOT** in the Hijack Mode:

(1). Normal Non-Hijack Operation (initial test state)

Provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to any of the interrogations.

(b). Does **NOT** emit squitter transmissions.

(c). Does **NOT** indicate that it **IS** in the Active Hijack Mode.

(2). Standard "7500" Code Entry (§2.2.27.1.1, §2.2.27.1.1.2.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "0" decimal, and **NO** SPI. Provide the transponder with an altitude input of 8,000 feet.

(a). Approximately 10 seconds after providing the 4096 Identity Code of "7500," verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the Airborne tests as called out in Part 3.a.

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Set the transponder to the Standby state and provide the transponder with a 4096 Identity Code of "7500."

Approximately 10 seconds after providing the 4096 Identity Code of "7500", verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing all the On-Ground tests as called out in Part 3.b.

(3). "7500" Code Entry with SPI (§2.2.27.1.2, §2.2.27.1.2.2.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7500" and a Sensitivity Level Control (SLC) of "0" decimal. Provide the transponder with an altitude input of 8,000 feet. As soon as possible, thereafter, initiate the SPI (Ident) function.

(a). Immediately after providing the SPI function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Set the transponder to the Standby state and provide the transponder with a 4096 Identity Code of "7500." As soon as possible, thereafter, initiate the SPI (Ident) function.

Immediately after providing the SPI function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

(4). Hijack Mode Discrete Initialization (§2.2.27.1.3, §2.2.27.1.3.2.b)

With the transponder in the Standby and Airborne states, provide the transponder with a 4096 Identity Code of "7777" and a Sensitivity Level Control (SLC) of "0" decimal. Provide the transponder with an altitude input of 8,000 feet. Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

(a). Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the Airborne General Requirements tests as called out in Part 3.a.(1).

(b). Provide the transponder with an altitude input of 500 feet and set the transponder to the On-Ground state.

Proceed to Part 3 of these test procedures and exit the Hijack Mode as called out in Part 3.b.(5).

(c). Set the transponder to the Standby state. Activate the Hijack Mode Discrete function for approximately one second, then deactivate the Hijack Mode Discrete function.

Immediately after activating the Hijack Mode Discrete function, verify that the transponder has entered the Active Hijack mode by proceeding to Part 3 of these test procedures and performing the On-Ground General Requirements tests as called out in Part 3.b.(1).

(d). Exit the Hijack Mode as called out in Part 3.b.(5) of these test procedures.

Part 3: Active Hijack Mode Operation (§2.2.27.2)

Note: *This procedure applies to the* ***Active On*** *transponder in a Dual Antenna Systems and Dual Diversity Transponder configuration and to both transponders in a Single Antenna System and Dual Diversity Transponder configuration.*

a. Airborne Testing

With the transponder being in the Active Hijack mode and the Airborne state, provide the transponder with a Sensitivity Level Control (SLC) of “0” decimal and an altitude input of 8,000 feet.

(1). General Requirements Tests (§2.2.27.2.1.a, b, §2.2.27.4.a)

Immediately after the transponder enters Active Hijack mode, interrogate the transponder with ATCRBS Mode-A, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=5, and UF=21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500.”

(b). Replies to all ATCRBS Mode-A interrogations with the SPI Pulse set for a period of 18 ±1 seconds.

(c). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(d). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

(e). Continues to emit squitter transmissions.

(f). Properly indicates that it **IS** in the Active Hijack Mode.

(g). Properly indicates the Alert Status in the "FS" field in accordance with Sections §2.2.14.4.14 and §2.2.18.2.7.

(2). Altitude Reporting Requirements Tests (§2.2.27.2.1.1)

(a). Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and UF=20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(b). Attempt to inhibit the Altitude Reporting function of the transponder. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and UF=20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(c). Provide the transponder with an INVALID altitude input of 10,000 feet. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and UF=20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with framing pulses only.

[2]. Replies to all UF 4, UF=20 Mode-S interrogations with an Altitude Field (AC) of all ZERO's.

(d). Restore the Valid altitude input of 8,000 feet.

(3). TCAS Communication Requirements Tests (§2.2.27.2.1.2)

(a). Provide the transponder with a Sensitivity Level Control (SLC) of "1" decimal.

Verify that the transponder (if TCAS equipped):

[1]. Properly provides the on-board TCAS with an SLC=1 decimal via the Transponder/TCAS interface

[2]. Properly provides the on-board TCAS with a 4096 Identity Code set to "7500."

(b). Provide the transponder with a Sensitivity Level Control (SLC) of "2" decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface.

(c). Provide the transponder with a Sensitivity Level Control (SLC) of "0" decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface.

(4). Loss of Control and Attempted Control Changes Tests (§2.2.27.2.1.c, and §2.2.27.2.3)

(a). Disable the capability to provide the transponder with a 4096 Identity Code of "7500", a Sensitivity Level Control (SLC) and other control functions. Ensure that the altitude reporting function of the transponder **IS** inhibited. (Note that if the Altitude Reporting function is selected via the control function, it should be inhibited automatically by removal of the control function capability).

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500" and **NO** SPI pulse.

[2]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

[3]. Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

[4]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

[5]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

[6]. Continues to emit squitter transmissions.

[7]. Does **NOT** provide TCAS with SLC, 4096 Identity Code or any other Control information since the Control Function has been lost.

Note: *The loss of control information to the TCAS Computer may result in a TCAS System fail if the test configuration is integrated with TCAS.*

[8]. Properly indicates that it **IS** in the Active Hijack Mode.

(b). Restore the control function capability to the transponder and set the control function to a setting that attempts to place the transponder into the Standby state. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500" and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(c). Provide the transponder with a 4096 Identity Code of "1200." Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(d). Provide the transponder with a valid altitude of 10,000 feet on the Alternate Air Data Source. Command the transponder to use the Alternate Air Data Source. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and 20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(e). Command the transponder to Functional Test mode. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(f). Activate the SPI command to the transponder. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=4, 5, 20 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Indicates that the SPI is **NOT** active in the FS field of DF=4, 5, 20 and 21 replies.

[4]. Properly indicates that it **IS** in the Active Hijack Mode.

(5). Attempted Hijack Mode Exit Verification (§2.2.27.5.1)

Activate the means to exit the Hijack Mode.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500" and **NO** SPI pulse.

(b). Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

(c). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(d). Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(e). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

(f). Continues to emit squitter transmissions.

(g). Properly provides the on-board TCAS (if TCAS equipped) with an SLC=2 decimal via the Transponder/TCAS interface.

(h). Properly provides the on-board TCAS (if TCAS equipped) with a 4096 Identity Code set to "7500."

(i). Properly indicates that it **IS** in the Active Hijack Mode.

b. On-Ground Testing

With the transponder being in the Active Hijack mode and the On-Ground state, provide the transponder with a Sensitivity Level Control (SLC) of "0" decimal and an altitude input of 500 feet.

(1). General Requirements Tests (§2.2.27.2.1.a, b, §2.2.27.2.2)

Immediately after the transponder enters Active Hijack mode, interrogate the transponder with ATCRBS Mode-A, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500" and **NO** SPI pulse.

(b). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(c). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

(d). Continues to emit squitter transmissions.

(e). Properly indicates that it **IS** in the Active Hijack Mode.

(f). Properly indicates the Alert Status in the "FS" field in accordance with Sections §2.2.14.4.14 and §2.2.18.2.7.

(2). Altitude Reporting Requirements Tests (§2.2.27.2.1.1)

(a). Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and 20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 500 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 500 feet.

(b). Attempt to inhibit the Altitude Reporting function of the transponder. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and 20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 500 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 500 feet.

(c). Provide the transponder with an INVALID altitude input of 1,000 feet. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and 20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations framing pulses only.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an Altitude Field (AC) set to all ZERO's.

(d). Restore the Valid altitude input of 500 feet.

(3). TCAS Communication Requirements Tests (§2.2.27.2.1.2)

(a). Provide the transponder with a Sensitivity Level Control (SLC) of "1" decimal.

Verify that the transponder (if TCAS equipped):

[1]. Properly provides the on-board TCAS with an SLC=1 decimal via the Transponder/TCAS interface

[2]. Properly provides the on-board TCAS with a 4096 Identity Code set to "7500."

(b). Provide the transponder with a Sensitivity Level Control (SLC) of "2" decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface.

(c). Provide the transponder with a Sensitivity Level Control (SLC) of "0" decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface

(4). Loss of Control and Attempted Control Changes Tests (§2.2.27.2.1.c, and §2.2.27.2.3)

(a). Disable the capability to provide the transponder with a 4096 Identity Code of "7500," a Sensitivity Level Control (SLC) and other control functions. Ensure that the altitude reporting function of the transponder IS inhibited. (Note that if the Altitude Reporting function is selected via the control function, it should be inhibited automatically by removal of the control function capability).

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500" and **NO** SPI pulse.

[2]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 500 feet.

[3]. Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

[4]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 500 feet.

[5]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

[6]. Continues to emit squitter transmissions.

[7]. Does **NOT** provide TCAS with SLC, 4096 Identity Code or any other Control information since the Control Function has been lost.

Note: *The loss of control information to the TCAS Computer may result in a TCAS System fail if the test configuration is integrated with TCAS.*

[8]. Properly indicates that it **IS** in the Active Hijack Mode.

(b). Restore the control function capability to the transponder and set the control function to a setting that attempts to place the transponder into the Standby state. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(c). Provide the transponder with a 4096 Identity Code of “1200.” Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(d). Provide the transponder with a valid altitude of 1,000 feet on the Alternate Air Data Source. Command the transponder to use the Alternate Air Data Source. Interrogate the transponder with ATCRBS Mode-C, Mode S UF=4 and 20 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 500 feet.

[2]. Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 500 feet.

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(e). Command the transponder to Functional Test mode. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Properly indicates that it **IS** in the Active Hijack Mode.

(f). Activate the SPI command to the transponder. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500” and **NO** SPI pulse.

[2]. Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

[3]. Indicates that the SPI is **NOT** active in the FS field of DF=4, 5, 20 and 21 replies.

[4]. Properly indicates that it **IS** in the Active Hijack Mode.

(5). Hijack Mode Exit Verification (§2.2.27.5.2)

Provide the transponder with a 4096 Identity Code of “7777.” Set the control function to an Active On setting. Activate the means to exit the Hijack Mode.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, or Mode S-only All-Call interrogations.

(b). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7777.”

(c). Indicates that the Hijack Mode Exit has been accomplished successfully.

(d). Properly indicates that it **IS NOT** in the Active Hijack Mode.

Part 4: Standby Hijack Mode Operation (§2.2.27.3)

Note: *This procedure applies to the **Standby** transponder in a Dual Antenna Systems and Dual Diversity Transponder configuration.*

a. Airborne Testing (§2.2.27.3.1)

With the transponder being in the Standby Hijack mode and Airborne states, provide the transponder with a Sensitivity Level Control (SLC) of “1” decimal, and an altitude input of 8,000 feet.

(1). General Requirements Tests (§2.2.27.3.1.b, c, d, §2.2.27.4.b)

Immediately after the transponder enters Standby Hijack mode, interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to any of the interrogations.

(b). Does **NOT** emit squitter transmissions.

(c). Properly indicates that it **IS** in the Standby Hijack Mode.

(2). TCAS Communication Requirements Tests (§2.2.27.3.2)

(a). Provide the transponder with a Sensitivity Level Control (SLC) of “1” decimal.

Verify that the transponder (if TCAS equipped):

[1]. Properly provides the on-board TCAS with an SLC = 1 decimal via the Transponder/TCAS interface

[2]. Properly provides the on-board TCAS with a 4096 Identity Code set to “7500.”

(b). Provide the transponder with a Sensitivity Level Control (SLC) of “2” decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC = 2 decimal via the Transponder/TCAS interface

(c). Provide the transponder with a Sensitivity Level Control (SLC) of “0” decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface

(3). Loss of Control and Attempted Control Changes Tests (§2.2.27.3.1.a, and §2.2.27.3.3)

(a). Disable the capability to provide the transponder with a 4096 Identity Code of “7500”, a Sensitivity Level Control (SLC) and other control functions. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Does **NOT** provide TCAS with SLC, 4096 Identity Code or any other Control information since the Control Function has been lost.

Note: *The loss of control information to the TCAS Computer may result in a TCAS System fail if the test configuration is integrated with TCAS.*

[4]. Properly indicates that it **IS** in the Standby Hijack Mode.

(b). Restore the control function capability to the transponder and set the control function to a setting that attempts to place the transponder into the Active On state. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Properly indicates that it **IS** in the Standby Hijack Mode.

(c). Command the transponder to Functional Test mode. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Properly indicates that it **IS** in the Standby Hijack Mode.

(4). Attempted Hijack Mode Exit Verification (§2.2.27.5.1)

Activate the means to exit the Standby Hijack Mode.

Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to any of the interrogations.

(b). Does **NOT** emit squitter transmissions.

(c). Properly provides the on-board TCAS (if TCAS equipped) with an SLC = 2 decimal via the Transponder/TCAS interface.

(d). Properly provides the on-board TCAS (if TCAS equipped) with a 4096 Identity Code set to "7500."

(e). Properly indicates that it **IS** in the Standby Hijack Mode.

b. On-Ground Testing

With the transponder being in the Standby Hijack mode and the On-Ground state, provide the transponder with a Sensitivity Level Control (SLC) of "1" decimal and an altitude input of 500 feet.

(1). General Requirements Tests (§2.2.27.3.1.b, c, d, §2.2.27.4.b)

Immediately after the transponder enters Standby Hijack mode, interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

(a). Does **NOT** reply to any of the interrogations.

(b). Does **NOT** emit squitter transmissions.

(c). Properly indicates that it **IS** in the Standby Hijack Mode.

(2). TCAS Communication Requirements Tests (§2.2.27.3.2)

(a). Provide the transponder with a Sensitivity Level Control (SLC) of “1” decimal.

Verify that the transponder (if TCAS equipped):

[1]. Properly provides the on-board TCAS with an SLC=1 decimal via the Transponder/TCAS interface.

[2]. Properly provides the on-board TCAS with a 4096 Identity Code set to “7500.”

(b). Provide the transponder with a Sensitivity Level Control (SLC) of “2” decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface.

(c). Provide the transponder with a Sensitivity Level Control (SLC) of “0” decimal.

Verify that the transponder (if TCAS equipped) properly provides the on-board TCAS with an SLC=2 decimal via the Transponder/TCAS interface.

(3). Loss of Control and Attempted Control Changes Tests (§2.2.27.3.1.a, and §2.2.27.3.3)

(a). Disable the capability to provide the transponder with a 4096 Identity Code of “7500,” a Sensitivity Level Control (SLC) and other control functions. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Does **NOT** provide TCAS with SLC, 4096 Identity Code or any other Control information since the Control Function has been lost.

Note: *The loss of control information to the TCAS Computer may result in a TCAS System fail if the test configuration is integrated with TCAS.*

[4]. Properly indicates that it **IS** in the Standby Hijack Mode.

(b). Restore the control function capability to the transponder and set the control function to a setting that attempts to place the transponder into the Active On state. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Properly indicates that it **IS** in the Standby Hijack Mode.

(c). Command the transponder to Functional Test mode. Interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder:

[1]. Does **NOT** reply to any of the interrogations.

[2]. Does **NOT** emit squitter transmissions.

[3]. Properly indicates that it **IS** in the Standby Hijack Mode.

(4). Hijack Mode Exit Verification (§2.2.27.5.2)

Provide the transponder with a 4096 Identity Code of "7777." Activate the means to exit the Hijack Mode.

Verify that the transponder:

(a). Indicates that the Hijack Mode Exit has been accomplished successfully.

(b). Properly indicates that it **IS NOT** in the Standby Hijack Mode.

Part 5: Power Interrupt Operations (§2.2.27.4.c, d, §2.2.27.6)

a. Normal Non-Hijack Operation (§2.2.27.4.c,d)

(1). Active On Mode

Set the transponder to the Active On state and **NOT** in the Hijack Mode.

Interrupt the power to the transponder for a period of approximately 1-2 seconds.

Verify that the transponder:

(a). Does **NOT** give a false indication that the Active Hijack mode is active.

(b). Does **NOT** give a false indication that the Standby Hijack mode is active (for transponders intended for installation in a Dual Antenna Systems and Dual Diversity Transponder configuration).

(2). Standby Mode

Set the transponder to the Standby state and **NOT** in the Hijack Mode.

Interrupt the power to the transponder for a period of approximately 1-2 seconds.

Verify that the transponder:

(a). Does **NOT** give a false indication that the Active Hijack mode is active.

(b). Does **NOT** give a false indication that the Standby Hijack mode is active (for transponders intended for installation in a Dual Antenna Systems and Dual Diversity Transponder configuration).

b. Active Hijack Mode (§2.2.27.6)

Note: *This procedure applies to the **Active On** transponder in a Dual Antenna Systems and Dual Diversity Transponder configuration and to both transponders in a Single Antenna Systems and Dual Diversity Transponder configuration.*

(1). Hijack Mode Initialization

With the transponder being in the Active On and Airborne states and **NOT** in the Hijack Mode, provide the transponder with a valid altitude input of 8,000 feet and a Sensitivity Level Control (SLC) of "0" decimal. Ensure that the altitude reporting function of the transponder IS inhibited. Then, initiate the Active Hijack mode via either of the methods identified in Part 1 or Part 2 of these test procedures.

After the transponder has entered the Active Hijack mode, interrogate the transponder with ATCRBS Mode-A, ATCRBS Mode-C, ATCRBS/Mode S All-Call, Mode S-only All-Call, Mode S UF=4, 5, 20, and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder properly annunciates that it **IS** in the Hijack Mode.

(2). Power Interruption:

Interrupt the power to transponder for a period of approximately 10 seconds. Retain the conditions applied to the transponder in Part 5.b.(1), except set the 4096 Identity Code to "7777." Then, restore power to the transponder.

Verify that the transponder:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of "7500."

(b). Replies to all ATCRBS Mode-A interrogations with the SPI Pulse set for a period of 18 ±1 seconds after restoration of power.

(c). Replies to all ATCRBS Mode-C interrogations with an encoded altitude of 8,000 feet.

(d). Replies to all ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations with an appropriate DF=11 Mode S reply.

(e). Replies to all UF=4, UF=20 Mode-S interrogations with an altitude of 8,000 feet.

(f). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of "7500."

(g). Properly provides the on-board TCAS (if TCAS equipped) with an SLC=2 decimal via the Transponder/TCAS interface.

(h). Properly provides the on-board TCAS (if TCAS equipped) with a 4096 Identity Code set to "7500."

(i). Properly annunciates that it **IS** in the Hijack Mode.

(3). On-Ground Hijack Mode Exit

Set the transponder to the On-Ground state and activate the means to exit the Hijack Mode.

Verify that the transponder:

(a). Indicates that the Hijack Mode Exit has been accomplished successfully.

(b). Properly annunciates that it **IS NOT** in the Active Hijack Mode.

c. Standby Hijack Mode (§2.2.27.6)

Note: *This procedure applies to the **Standby** transponder in a Dual Antenna Systems and Dual Diversity Transponders configuration.*

(1). Standby Hijack Mode Initialization

With the transponder being in the Standby and Airborne states and **NOT** in the "Standby Hijack" mode, initiate the Standby Hijack mode via either of the methods identified in Part 1 of these test procedures.

At least 10 seconds after initiating the Hijack Mode, verify that the transponder properly indicates that it **IS** in the Standby Hijack Mode.

(2). Power Interruption:

Interrupt the power to transponder for a period of approximately 10 seconds. Retain the conditions applied to the transponder in Part

5.c.(1), except set the 4096 Identity Code to "7777." Then, restore power to the transponder.

Verify that the transponder:

(a). Properly annunciates that it **IS** in the Standby Hijack Mode.

(3). On-Ground Hijack Mode Exit

Set the transponder to the On-Ground state and activate the means to exit the Hijack Mode.

Verify that the transponder:

(a). Indicates that the Hijack Mode Exit has been accomplished successfully.

(b). Properly annunciates that it **IS NOT** in the Standby Hijack Mode.

3.1.2 Inadvertent Turn Off

Protection **shall** be provided to prevent the inadvertent turn off of the equipment. Where Hijack functions are provided, to ensure continuous electrical power to the transponders, it **shall** be demonstrated that when the Hijack Mode is triggered that unauthorized removal of electrical power to the transponders, via the flight deck circuit breakers, **shall not** affect the continuous operation of the transponder to output the Hijack Code in both Mode A and Mode S replies.

3.1.4 Aircraft Power Source

The voltage and voltage tolerance characteristics of the equipment **shall** be compatible with the aircraft power source of appropriate category as specified in RTCA/DO-160E.

3.1.4.1 Normal Equipment Operations

The aircraft installation **shall** ensure that appropriate voltage and voltage characteristics required by the transponder equipment **shall** be continuously applied to the transponder equipment at all times that the transponder equipment is required to be operational.

Note: *This requirement does not apply in situations where power to the transponder equipment must be interrupted in order to prevent possible fire conditions or other emergency conditions determined by the Flight Crew.*

3.1.4.2 Hijack Mode Equipment Operations

The aircraft installation **shall** apply all reasonable measures to ensure that appropriate voltage and voltage characteristics required by the transponder equipment **shall** be continuously applied to the transponder equipment at all times that the transponder equipment is functioning in the Hijack Mode. This applies to both the Active On and the Standby transponder equipment.

Note: *This requirement does not apply in situations where power to the transponder equipment must be interrupted in order to prevent possible fire conditions or other emergency conditions determined by the Flight Crew.*

3.1.8 Single Operational Transponder at One Time

a. The aircraft installation **shall** ensure that **ONLY ONE** transponder is coupled to the antenna system and capable of delivering interrogation replies or squitter transmissions from the aircraft at **ANY** given time.

b. The aircraft installation **shall** ensure that **NO** transponder is improperly connected to its antenna system or left in an open-circuit transmission state in which the transponder could emit excessive RF energy into **ANY** aircraft compartment.

3.3.16 Single Operational Transponder at One Time

Verify:

a. That **ONLY ONE** transponder and associated antenna system is capable of delivering interrogation replies or squitter transmissions from the aircraft at **ANY** given time, and

b. That **NO** transponder is capable of radiating RF energy into any compartment of the aircraft due to improper connection to the antenna system or radiation into an open-circuit.

3.3.17 Hijack Mode Operations

Note: *The following requirements apply to the Hijack Mode function only when implemented internal to the Mode-S Transponder unit.*

Perform the following installed test sequence independently for each transponder in the installation.

a. Hijack Mode Initialization, Verification, and Exit – Configuration One

Note: *This procedure applies to the **Active On** transponder in a Dual Antenna Systems and Dual Diversity Transponder configuration and to both transponders in a Single Antenna System and Dual Diversity Transponder configuration.*

(1). Hijack Mode Initialization and Verification – Configuration One

With the transponder being in the Active On and Airborne states and **NOT** in the Hijack Mode, initiate the Hijack Mode via all of the installed methods identified in §2.2.27.1.1, §2.2.27.1.2, or §2.2.27.1.3.

At least ten seconds after initiating the Hijack Mode, interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder system:

(a). Replies to all ATCRBS Mode-A interrogations with the 4096 Identity Code of “7500.”

(b). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “7500.”

(c). Properly indicates that it **IS** in the Hijack Mode.

(2). Hijack Mode Exit– Configuration One

Starting with the conditions as they existed after §3.3.17.a.(1).(c)., provide the transponder with a 4096 Identity Code of “6767,” set the transponder to the On-Ground state and activate the means to exit the Hijack Mode. Interrogate the transponder with ATCRBS Mode-A, Mode S UF=5, UF=21 interrogations for a minimum period of 20 seconds.

Verify that the transponder system:

(a). Replies to all UF=5, UF=21 Mode-S interrogations with an ID field of “6767.”

(b). Properly indicates that it **IS NOT** in the Hijack Mode.

b. Standby Hijack Mode Initialization, Verification, and Exit – Configuration Two

Note: *This procedure applies to* ***Standby*** *transponders intended for Dual Antenna System and Dual Diversity Transponder configurations.*

(1). Standby Hijack Mode Initialization – Configuration Two

With the transponder being in the Standby and Airborne states and **NOT** in the Standby Hijack Mode, initiate the Hijack Mode via all of the installed methods identified in §2.2.27.1.1, §2.2.27.1.2, or §2.2.27.1.3.

At least ten seconds after initiating the Hijack Mode, verify that the transponder properly indicates that it **IS** in the Standby Hijack Mode.

(2). Standby Hijack Mode Verification – Configuration Two

Attempt to place the transponder into the Active On mode and interrogate the transponder with ATCRBS Mode-A, Mode S UF=5 and 21 interrogations for a minimum period of 20 seconds.

Verify that the transponder system:

(a). Does **NOT** reply to any of the interrogations.

(b). Properly indicates that it **IS** in the Standby Hijack Mode.

(3). Standby Hijack Mode Exit – Configuration Two

Ensure that the 4096 code provided to the transponder is set to a setting other than “7500.”

Set the transponder to the Standby and On-Ground states, then Activate the means to exit the Hijack Mode.

Verify that the transponder properly indicates that it **IS NOT** in the Standby Hijack Mode.

Appendix E

Details of the Changes from DO-181D to DO-181E

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Executive Summary

The update to the *Minimum Operational Performance Standards (MOPS) for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment*, published by RTCA on October 2, 2008 as RTCA DO-181D, is contained herein as **The Details of the Changes from RTCA DO-181D to DO-181E**, and has been produced to reflect the changes that have resulted in requirements and test procedures for airborne transponder equipment.

This **Appendix** represents **The Details of the Changes from RTCA DO-181D to DO-181E**. RTCA Special Committee 209 (SC-209) and EUROCAE Working Group 49 (WG-49) were reconvened for the purpose of updating their respective Transponder MOPS documents to include changes that were necessary to reflect other changes that were made when the ADS-B MOPS documents (RTCA DO-260B and EUROCAE ED-102A) were published in December 2009.

The primary changes to the ADS-B MOPS that required modifications to the Transponder MOPS dealt with:

1. The changes to the characteristics of the ADS-B Target State and Status (Register 62_{16}) and the Aircraft Operational Status (Register 65_{16}) Messages, which were removed from under the Event-Driven Protocol and given specific broadcast rates as Periodic Status Messages. Additional issues relate to resolving the requirements related to timeout and termination of these Registers.
2. The changes to the specification for the maximum number of squitters from a hard limit of 6.2 per second to "6.2 per second averaged over any 60 second interval, except during an emergency condition."
3. The changes to the timeout and termination of the ADS-B Velocity Message.
4. The changes to Transponder MOPS test procedures to more closely align with those in the ADS-B MOPS (RTCA DO-260B and EUROCAE ED-102A).

There were additional changes that were required to the Transponder MOPS to correct errors that have been discovered in the test procedures and certain other typographical errors uncovered by manufacturers as they have implemented transponders compliant with RTCA DO-181D.

Additionally, the ICAO Aeronautical Surveillance Panel Technical Subgroup identified and discussed issues that have been reported by Civil Aviation Authorities since the publication of RTCA DO-181D in October 2008 and there were changes to the Transponder MOPS documents that were requested to be discussed and resolved in the following areas:

a. To clarify the differences in the treatment of the ADS-B Identification Register 08_{16} and the Enhanced Surveillance (EHS) Identification Register 20_{16}.

b. To resolve the issues that have led to Mode S interrogators in Europe that support EHS receiving the contents of a Register that was not requested. This issue has come to be referred to as "BDS Swap."

c. To resolve the issue of how a Transponder should reply to an unassigned DI Codes.

d. To clarify the reply rate requirements in the ICAO SARPs and Transponder MOPS and potentially adopt changes to clarify current requirements.

e. Clarified the Transponder processing for the Comm-B Protocol and enhanced the test procedures.

f. To propose language to strengthen the Flight ID requirements such that the display of Flight ID and the crew entry must be simple to access and modify both on-the-ground and in flight.

g. To enhance aircraft monitoring by defining a clear set of parameters in a newly defined Register for Transponder maintenance and diagnostics.

h. To specify changes in the Mode S Subnetwork Version Number as a result of the proposed changes to the Transponder MOPS and the corresponding changes that are being specified for the ICAO Doc 9871, Edition 2 to correspond to ADS-B Version 2 formats.

i. To provide a means to control the on-the-ground condition for aircraft operating without a squat switch and to clearly indicate that when on the surface that all surface format messages would be broadcast if so commanded. Resolution of these issues led to changes in the TCS and RCS commands. Additional changes to the RCS command removed the ability to inadvertently suppress the broadcast of Extended Squitters.

j. To investigate and potentially attempt to resolve issues raised by a signal-in-space study commissioned by EASA related to measuring and analyzing the actual signal-in-space as it exists in several parts of the European airspace with respect to radar and transponder performance. This issue came to be known as the I/Q modulation issue.

k. To clarify that the transponder should interpret multisite lockout in an interrogation where DI=1, 7, and non-selective lockout in the same interrogation, where PC=1, and set the T_D and appropriate T_L timers accordingly from that single interrogation.

l. To discuss the elimination of the requirement to reply to a wide P4 interrogation. This resulted in clarifying notes to be added to warn manufacturers that the $P4_{LONG}$ may be eliminated in a future version of the Transponder MOPS.

E. Details of the Changes from RTCA DO-181D to DO-181E

Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment

This Appendix prescribes the Minimum Operational Performance Standards (MOPS) for airborne transponder equipment, modified as described in this Appendix. The applicable standards basis for those changes requested in this Appendix is RTCA DO-181D, "*Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment,"* issued October 2, 2008.

This Appendix was originally prepared as a "Change 1 to DO-181D." However, during the course of development, both RTCA and EUROCAE made the decision to completely reissue the Transponder MOPS documents in light of the number of significant changes made. In order to indicate to the reader exactly what changes were made between RTCA DO-181D and RTCA DO-181E, this Appendix will use change numbers such as (**1.1**) through (**1.xxx**), to describe specific changes made to create RTCA DO-181E.

In the following requested changes, for those items where existing text is requested to change, the new text is underlined and highlighted in blue, and deleted text is presented in ~~strikethrough and red text~~. In those changes where a totally new section or text is inserted, all the text is presented in underline and highlighted in blue.

(**1.1**) In RTCA DO-181D, in section §1.4.3.1, correct the spelling of the word "prescribed" in the bullet-list lead-in sentence, and replace bullet "b" with the following:

b. ATCRBS/Mode-S all-call and Mode S-only all-call transactions,

(**1.2**) In RTCA DO-181D, in numerous sections, beginning with §1.4.3.2 a method is described, which is referred to as the "Overlay Command Capability," to address a problem identified in both European and US airspace, known as the "BDS Swap Issue," where interrogators have been found to receive the contents of a Register that was not requested. Proposed changes to the Transponder MOPS documents are based on first receiving a command bit from the interrogator to overlay Register information over the 24-bit address/parity in the reply to the interrogation. The parity is established by first performing a Modulo-2 Sum using the most significant 8 bits of the Address ("AA") field with the Register number. The results are then used to generate a Data Parity (DP) field in the same manner that the AP field is currently generated. To prevent impact to current interrogators and transponders in the field, the method also provides for the transponder to annunciate capability to support the DP field. All of the proposed changes are identified in Working Paper SC209-WP14-05R3.

(**1.3**) In RTCA DO-181D, in section §1.4.6, in the text of "Example 2," in the third line:

Replace "*125 wats*" **with** "*125 watts*"

(**1.4**) In RTCA DO-181D, in section §2.1.7, in order to strengthen the Flight ID requirements such that the display and crew entry must be simple to access and modify while on the ground or during flight, make the following changes to subparagraph "f:"

f. If the aircraft uses a flight number for aircraft identification, a means **shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground, or during flight. The means for modifying and displaying aircraft identification **shall** be a simple crew action independent of the entry of other flight data.

(**1.5**) In RTCA DO-181D, in section §2.1.11.1, in order to clarify that different types of modulators could be used to generate the phase reversal and that a diode detector can only be used for test purposes as described in Working Paper SC209-WP12-15R2, add the following *Note* just after bullet "b" and prior to §2.1.11.2:

Note: *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop, but with a frequency shift of several MHz during the phase reversal.*

(**1.6**) In RTCA DO-181D, in section §2.1.11.4.3, in order to clarify that different types of modulators could be used to generate the phase reversal and that a diode detector can only be used for test purposes as described in Working Paper SC209-WP12-15R2, add the following *Note* just after the text of the paragraph and prior to §2.1.11.4.4:

Note: *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop, but with frequency shift during the phase reversal and slow phase reversal (80ns).*

(**1.7**) In RTCA DO-181D, in section §2.1.11.4.4, in order to correct a value in the spacing section for the P5 pulse to sync phase reversal, make the following change:

P5 to sync phase reversal 0.40 +/- ~~0.1~~ 0.05

(**1.8**) In RTCA DO-181D, in section §2.2.2.1, in order to clarify that different types of modulators could be used to generate the phase reversal and that a diode detector can only be used for test purposes as described in Working Paper SC209-WP12-15R2, add the following *Notes* just after the text of the paragraph and prior to §2.2.2.2:

Notes:

1. *The 1030 MHz transmitter can generate phase reversal using different methods. This includes hard keying with strong amplitude drop and rapid phase reversal or IQ modulation with little or no amplitude drop, but with frequency shift during the phase reversal and slow phase reversal (80ns).*

2. *The transponder cannot make any assumption on the type of modulation technology used and therefore cannot rely on the specificities of the signal during the phase reversal to detect a phase reversal.*

(**1.9**) In RTCA DO-181D, in section §2.2.2.4.f, in order to harmonize with the same requirement stated in EUROCAE ED-73C, §3.2.4.f, and to be consistent with the established test procedure already in RTCA DO-181D in §2.4.2.1, Step 3, make the following addition to sub-bullet "f:"

f. The reply ratio **shall** be at least 90 percent for ATCRBS and ATCRBS/Mode S All-Call interrogations between MTL +3 dB and -21 dBm.

(**1.10**) In RTCA DO-181D, in section §2.2.3.3, *Note #2* expresses a requirement that is based in ICAO Annex 10, Volume 4, §4.3.11.f. This requirement is stated again in §2.2.22.f. Since requirements cannot exist inside a *Note*, edit *Note #2* as follows:

2. *If the transponder is used in conjunction with TCAS equipment, the RF power in the inactive state at 1090 +/- 3 MHz at the terminals of the Mode S transponder antenna ~~shall~~ must not exceed -70 dBm in accordance with §2.2.22.f.*

(**1.11**) In RTCA DO-181D, in section §2.2.3.4.1, in order to clarify the requirement for reply rate, insert a second note at the end of the paragraph as follows:

Notes:

1. *A 15 pulse reply includes 2 framing pulses, the 12 information pulses, and the SPI pulse.*
2. *The reply rate requirement of 500 replies per second establishes the minimum continuous reply rate capability of the transponder. As per the altitude and speed criteria above, the 100 or 120 replies in a 100 millisecond interval defines the peak capability of the transponder. The transponder must be capable of replying to this short term burst rate, but may not be capable of sustaining this rate. If the transponder is subjected to interrogation rates beyond its reply rate capability, the reply rate limit control of §2.2.7.3.1 acts to gracefully desensitize the transponder in a manner that favors closer interrogators. Desensitization eliminates weaker interrogation signals.*

(**1.12**) In RTCA DO-181D, in section §2.2.4.2.5.b, insert the text as described below:

b. At all RF input levels from MTL to -21 dBm, the first preamble pulse of the reply **shall** occur 128 ±0.5 microseconds after the leading edge of the P4 pulse of the ATCRBS/Mode S All-Call interrogation. At all RF input levels from MTL +3 dB to -21 dBm, the jitter of the reply delay **shall not** exceed ±0.1 microsecond, peak (99.9 percentile).

(**1.13**) In RTCA DO-181D, in section §2.2.10.2, replace the contents of the paragraph with the following edited text:

A squitter monitor **shall** be provided to verify that the Mode S transponder generates short and Extended Squitters at their nominal rates (see §2.2.18.2.6 and §2.2.23.1). Event Driven Squitter rates are not required to be monitored to meet this requirement. The transponder **shall** be considered failed when the monitor has detected squitter failure.

(**1.14**) In RTCA DO-181D, in section §2.2.13.1.2, in order to strengthen the Flight ID requirements such that the display and crew entry must be simple to access and modify while on the ground or during flight, make the following changes to subparagraph "e:"

e. If the aircraft uses a flight number for aircraft identification, a means **shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground, or during flight. The means for modifying and displaying aircraft identification **shall** be a simple crew action independent of the entry of other flight data.

(**1.15**) In RTCA DO-181D, in section §2.2.14.4.28, in order to clarify the regular use of non-selective lockout to block mistaken replies to ATCRBS-only All-Call, as identified in Working Paper SC209-WP11-16, make the following changes in the paragraph after the table describing the PC Code definitions.

The PC field values 2 through 7 shall be ignored and the values 0 and 1 **shall** be processed for the processing of surveillance or Comm-A interrogations containing DI=3 (see §2.2.19.2.1.1).

(**1.16**) In RTCA DO-181D, in section §2.2.18.2.1.c, in order to correct a bad paragraph reference to the function G(x), make the following correction:

Replace "G(x) is defined in 2.2.16.2.1 b." **with** "G(x) is defined in §2.2.18.2.1.b"

(**1.17**) In RTCA DO-181D, in section §2.2.18.2.2.c, in order to inform the Transponder community that there is a possibility that the P4 Long will be eliminated sometime in the future, as specified in Working Paper SC209-WP13-09R1, add a *Note* after the text of bullet "c." Additionally, in order to harmonize the text of bullet "c" with EUROCAE ED-73(), make the following addition of text to the end of bullet "c."

c. ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) shall be accepted unless the TD timer is running or side lobe suppression is in effect or when in the "on-the-ground" state (consistent with the CA, VS and FS fields).

Note: *The acceptance of ATCRBS/Mode S All Call interrogations may be disabled in a future version of these MOPS.*

(**1.18**) In RTCA DO-181D, in section §2.2.18.2.3, add a line to the table, and delete the last sentence in the paragraph as follows:

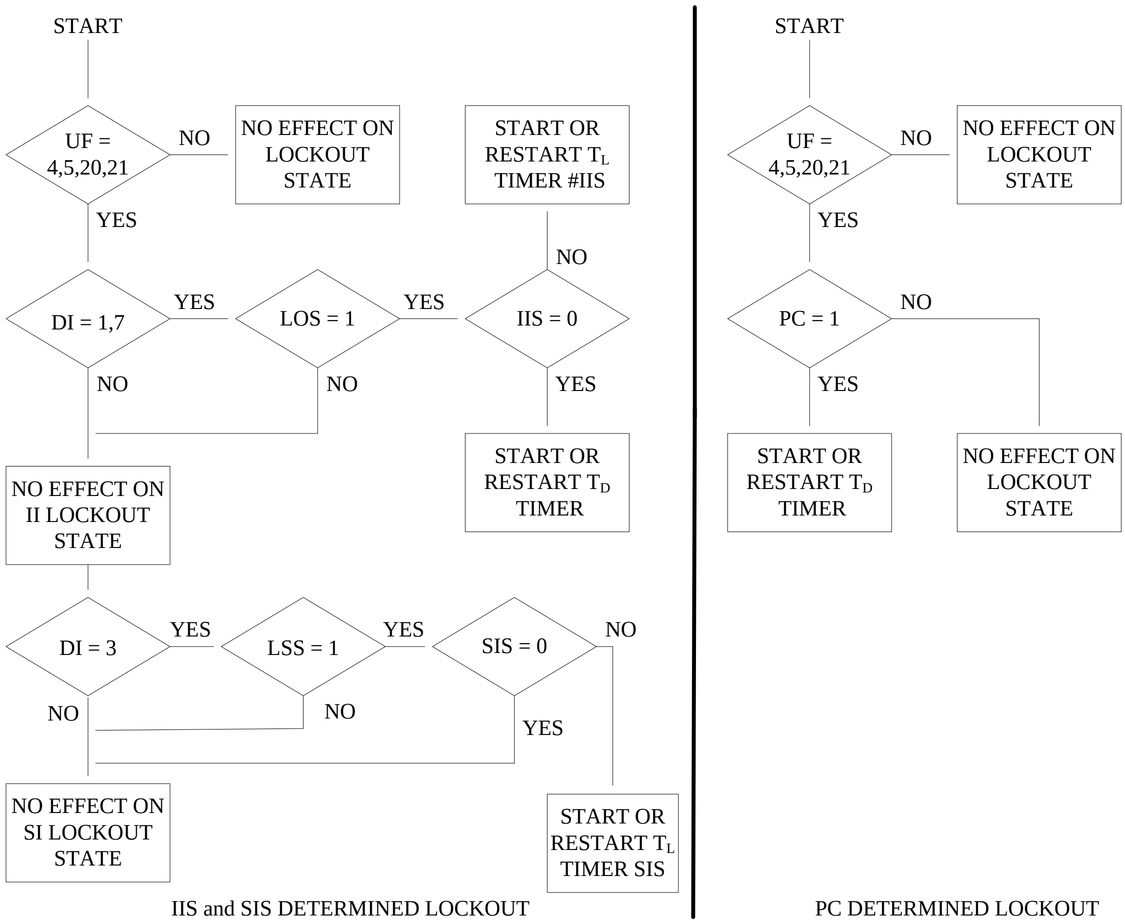
Interrogations	**Replies**
ATCRBS Mode A	4096 Codes
ATCRBS Mode C	Altitude Codes
ATCRBS Mode A/Mode S All-Call	Reply is DF=11
ATCRBS Mode C/Mode S All-Call	Reply is DF=11
Mode S-only All-Call (UF=11)	Reply is DF=11

~~For all Mode S interrogations the reply format number (DF) shall be the same as the interrogation format number (UF).~~

(**1.19**) In RTCA DO-181D, in section §2.2.18.2.4, in order to clarify the regular use of non-selective lockout to block mistaken replies to ATCRBS-only All-Call, as identified in Working Paper SC209-WP11-16, and modified during final comment resolution during Meeting #14, and recorded in ICAO ASP TSG Working Paper TSGWP10-12R1, add the following *Note* after the second paragraph and prior to Figure 2-13:

Note: *Non-selective All-Call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. The non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected ATCRBS/Mode S All-Call interrogations from ATCRBS-Only All-Call interrogations because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.*

(**1.20**) In RTCA DO-181D, in section §2.2.18.2.4, in order to clarify the regular use of non-selective lockout to block mistaken replies to ATCRBS-only All-Call, as identified in Working Paper SC209-WP11-16, and to make clear that the transponder should interpret multisite lockout in an interrogation where DI=1, 7, and non-selective lockout in the same interrogation where PC=1, and set the T_D and appropriate T_L timers accordingly from that single interrogation, replace Figure 2-13 with the following:



Note: For actions of T_D – T_L and IIS, see acceptance protocol.

Figure 2-13: All Transponders: Lockout Initiation

(**1.21**) In RTCA DO-181D, in section §2.2.18.2.5, in order to clarify the regular use of non-selective lockout to block mistaken replies to ATCRBS-only All-Call, as identified in Working Paper SC209-WP11-16, and modified during final comment resolution during Meeting #14, and recorded in ICAO ASP TSG Working Paper TSGWP10-12R1, prior to §2.2.18.2.6, add the following as *Note #3*:

Note 3: *Non-selective All-Call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. The non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected ATCRBS/Mode S All-Call interrogations from ATCRBS-Only All-Call interrogations because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.*

(**1.22**) In RTCA /DO-181D, in section §2.2.18.2.6, in order to clarify the use of the TCS command to control Extended Squitter broadcasts, as identified in Working Paper SC209-WP11-12R1, make the following edits to subparagraph "c" as follows:

c. Conditions for Acquisition Squitter Transmission – The following applies to transponders transmitting Extended Squitters. When commanded to report the surface ~~position~~ type formats by TCS commands (see §2.2.23.1.7), aircraft without automatic means of determining the on-the-ground condition, and aircraft with such means that are reporting airborne state, **shall** transmit acquisition squitters in addition to the surface ~~position~~ Extended Squitter formats unless acquisition squitter transmission has been inhibited (subparagraph d.).

Note 1: *This action is taken to ensure TCAS acquisition in the event that the ground station inadvertently commands an airborne aircraft to report the surface ~~position type of~~ Extended Squitter formats.*

If aircraft are commanded to stop emitting surface ~~position~~ Extended Squitter formats by RCS command equal to 3 or 4 (see §2.2.23.1.7), these aircraft **shall** begin to emit the acquisition squitter (if not already doing so).

(**1.23**) In RTCA DO-181D, in section §2.2.18.2.7, in bullet "a" just after *Note 1*, add the following new requirement:

When the transponder transitions to normal operation (see §2.1.7.c) it **shall** initiate a temporary alert for 18 ±1 seconds.

(**1.24**) In RTCA DO-181D, in section §2.2.19.1, replace the contents of bullets "a," "b," and "c" with the following edited text:

a. Process uplink and downlink formats DF=16, UF=DF=~~16,~~ 20 and 21 (Figure 2-14). The format~~s~~ UF=~~DF=~~16 ~~are~~ is optional:

Note: ~~DF=16 is available in transponders supporting Crosslink capability (see §2.2.14.4.7).~~ UF=16 is supported by transponders connected to an on-board operational TCAS (see §2.2.22).

b. Receive broadcast transmissions from sensors (§2.2.19.1.11).

c. Follow the protocols for:

Comm-A (see §2.2.19.1.10).
Comm-B (see §2.2.19.1.12).
Comm-U/V (air-air) (see §2.2.19.1.16) ~~(optional)~~.
Multisite message operation (see §2.2.19.2).
Report Codes 4 through 7 in the CA field (see §2.2.14.4.6).
TCAS crosslink capability (see §2.2.19.1.18).

(**1.25**) In RTCA DO-181D, in section §2.2.19.1.4, replace the first table with the table below and add a new *Note* below the table as follows:

Interrogation	**Reply**
ATCRBS Mode A (see Note)	4096 Code
ATCRBS Mode C (see Note)	Altitude Code
ATCRBS/Mode S All-Calls (see Note)	DF=11
UF=4 and UF=5	as below
UF=11 (see Note)	DF=11
UF=20 and UF=21	as below
Broadcast	None

Note: *The transponder does not reply when the conditions of §2.2.18.2.3 apply.*

(**1.26**) In RTCA DO-181D, in section §2.2.19.1.6, as identified in Working Paper SC209-WP11-20R1, replace Figure 2-17 with the following:

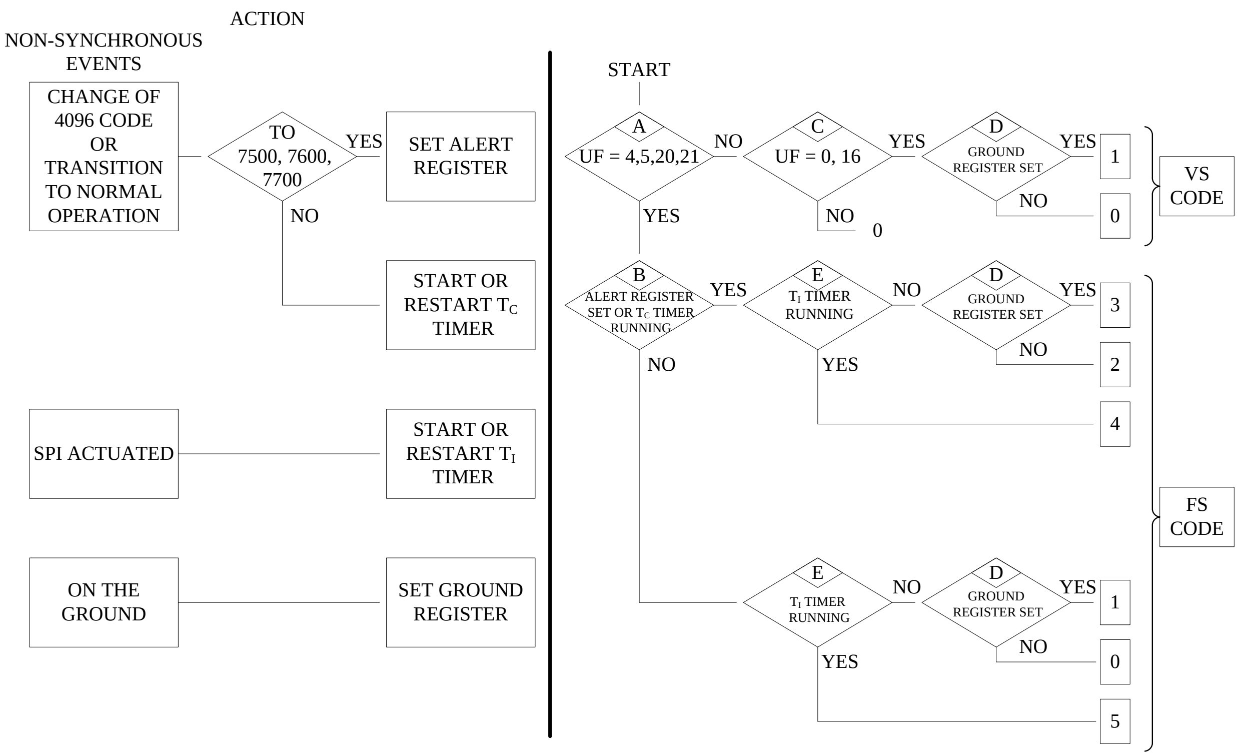


Figure 2-17: All Transponders: FS and VS Protocol

(**1.27**) In RTCA DO-181D, in section §2.2.19.1.11, in the first sentence of the paragraph, in order to correct a bad reference:

Change §2.2.18.2.2 **to** §2.2.19.1.1

(**1.28**) In RTCA DO-181D, in section §2.2.19.1.12, as noted in Working Paper SC209-WP12-08R1, to account for DI=3, changes were made in Figure 2-20. Additional changes were made with Working Paper SC209-WP14-05R3 for the BDS Swap issue.

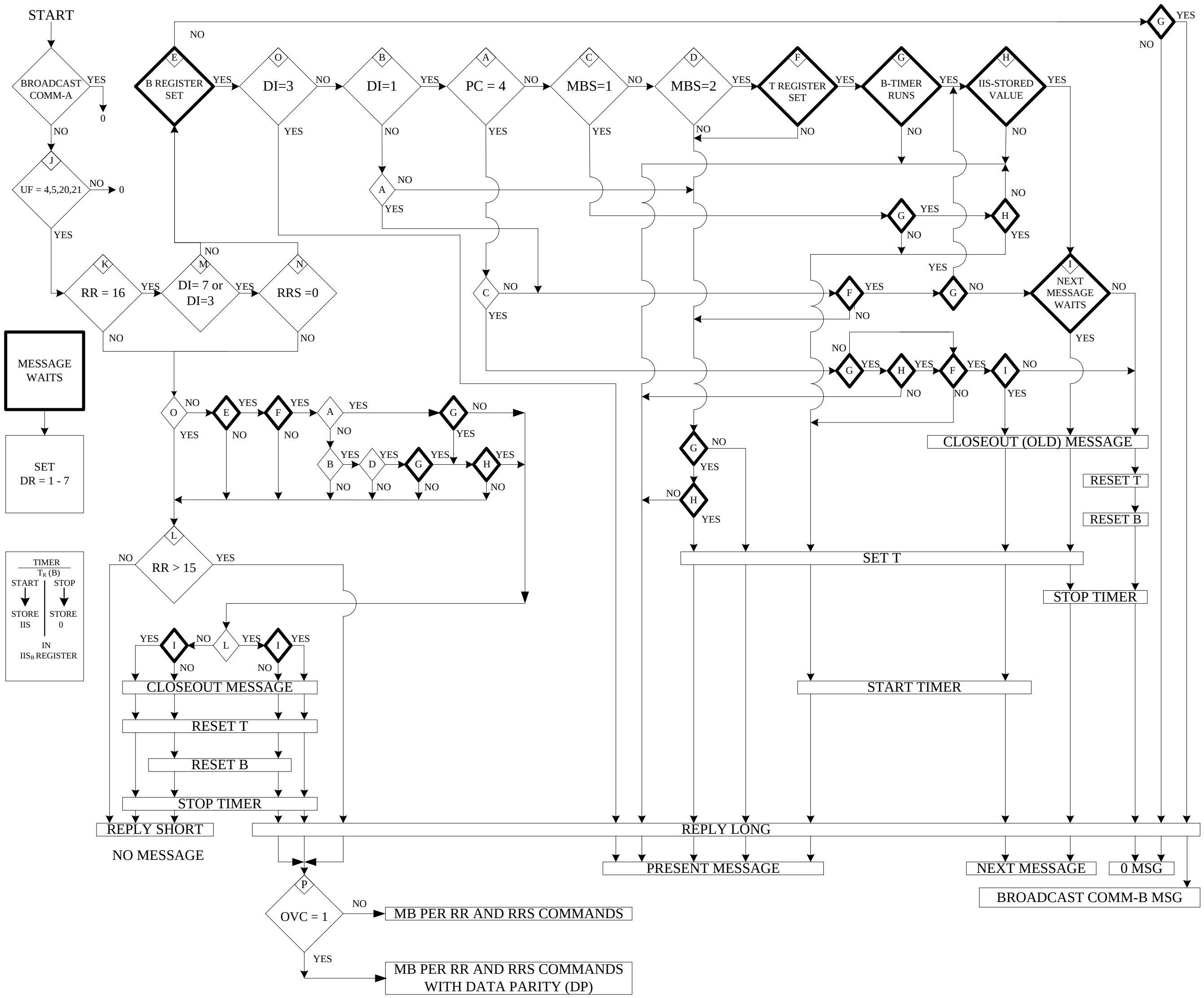


Figure 2-20: All Data Link Transponders: B-Protocol

(**1.29**) In RTCA DO-181D, in section §2.2.19.1.12.4, in order to comply with changes to the Comm-B protocol made after review of Working Paper SC209-WP12-08R1, and to delete a bad reference held over from earlier versions of DO-181, make the following edits to the paragraph:

An air-initiated Comm-B sequence **shall** start upon the acceptance of a message intended for delivery to the ground sensor. After receipt of this message, the transponder **shall** insert codes 1 or 3 in the DR field of a surveillance or Comm-B reply, DF=4, 5, 20, 21. On receipt of this announcement, the interrogator transmits code 16 with DI≠7 or with DI=7 and RRS=0 in the RR field of a subsequent interrogation. This includes when DI=4, 5 or 6, which are currently reserved. Receipt of this code by the transponder **shall** constitute the authorization to transmit the data. The resulting MB field contains a code identifying the content of the field. This reply, and others following it, **shall** continue to contain codes 1 or 3 in the DR field. After the message has been transmitted at least once in response to an interrogation using non-selective protocols ~~(see §2.2.17.2.3.4)~~ and after closeout is received (Code 4 in the PC field) in UF=4, 5, 20, 21, the transaction **shall** be closed out and the DR code belonging to this message immediately removed. Another message waiting to be transmitted can then set the DR code to 1 or 3 so that the reply can contain the announcement of this next message. If RR=16 with DI≠7, or with DI=7 and RRS=0, is received while no message is waiting to be transmitted, the reply **shall** contain all ZEROs in the MB field. An interrogation with DI=3 **shall not** affect the state of the Air-Initiated Comm-B protocol.

(**1.30**) In RTCA DO-181D, in section §2.2.19.1.12.5, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, make the following changes in the first paragraph after the *Note*:

A Comm-B broadcast starts, when no air-initiated Comm-B transaction is in effect, with the insertion of DR codes 4, 5, 6 or 7 into downlink transmissions of DFs 4, 5, 20, 21 and with the starting of the B-timer. On receipt of the above DR codes, interrogators may extract the broadcast message by transmitting RR=16 with DI≠3 or 7, or with DI=3 or 7 and RRS=0 in subsequent interrogations. When the B-timer runs out after 18 ±1 seconds, the transponder will reset the DR codes as required, will discard the previous broadcast message and change from 1 to 2 (or vice versa) the broadcast message number.

(**1.31**) In RTCA DO-181D, in section §2.2.19.1.18, in order to correct a bad paragraph reference, and also make revisions related to the GICB revisions discussed in Working Paper TSG WP08-02R1, revise the paragraph as follows:

In response to a UF=0 with RL=1 (see §2.2.14.4.33) and DS≠0 (see §2.2.14.4.13), the transponder **shall** reply with a DF=16 reply in which the MV field **shall** contain the contents of the ground-initiated Comm-B register designated by the DS value. If the requested Register is not supported by the aircraft installation, then the transponder **shall** reply with an MV field containing ALL ZEROs. In response to a UF=0 with RL=1 and DS=0, the transponder **shall** reply with a DF=16 with an MV field of ALL ZEROs. Receipt of a UF=0 with DS≠0, but RL=0 **shall** have no associated TCAS crosslink action, and the transponder **shall** reply per §2.2.14.4.33.

(**1.32**) In RTCA DO-181D, in section §2.2.19.2.1.1, in order to comply with changes to the Comm-B protocol contained in Working Paper SC209-WP12-08R1, add subparagraph "g:"

g. If DI=4, 5 or 6 then the SD field has no meaning and shall not impact other transaction cycle protocols. These DI codes remain reserved until future assignment of the SD field.

(**1.33**) In RTCA DO-181D, in section §2.2.21.1.4, as noted in Working Paper SC209-WP12-08R1, to account for DI=3, changes were made in Figure 2-25. Additional changes were made with Working Paper SC209-WP14-05R3 for the BDS Swap issue.

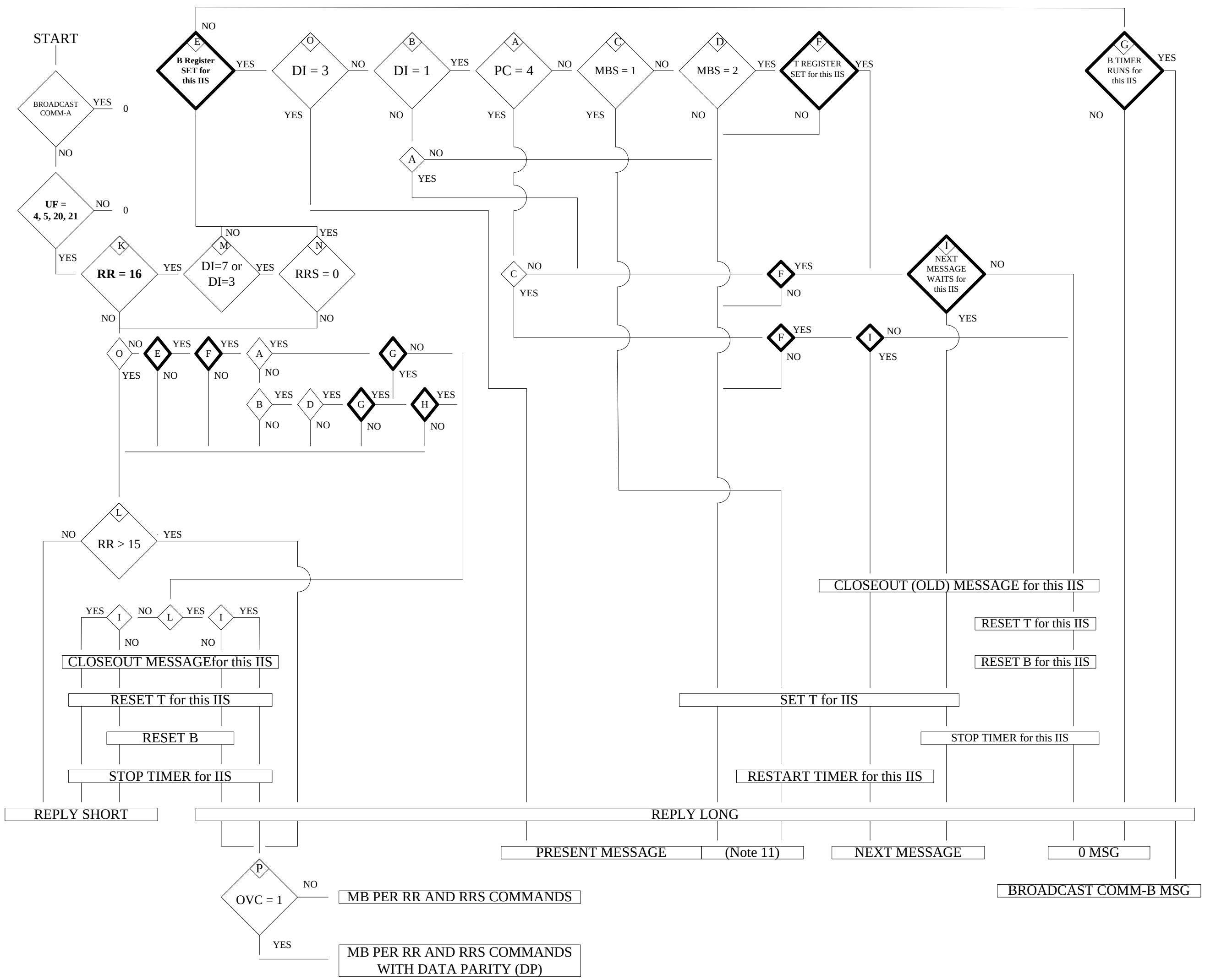


Figure 2-25: Enhanced Comm-B Protocol

(**1.34**) In RTCA DO-181D, in section §2.2.22.f there is a requirement that is based in ICAO Annex 10, Volume 4 §4.3.11.1.f, except that in order to be consistent with §4.3.11.1.f and EUROCAE ED-73C, §3.27.f, the text of the requirement must be edited as follows:

f. RF performance compatibility with own aircraft's TCAS. Specifically, when the Mode S transponder transmitter is in the inactive state, the RF power at 1090 +/- 3 MHz at the terminals of the Mode S transponder antenna **shall not** exceed -70 dBm.

(**1.35**) In RTCA DO-181D, in section §2.2.22.1.2.1.1, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, make the following changes in the third paragraph:

Upon receipt of a DF=4, 5, 20, or 21 reply, with DR=2, 3, 6 or 7, a Mode S sensor may request downlink of the RA Report by setting RR=19 and DI≠3 or 7, or RR=19, DI=3 or 7 and RRS=0 in a surveillance or Comm-A interrogation (UF=4, 5, 20, or 21) to the TCAS aircraft. When this request is received by own Mode S transponder, own transponder shall reply with a Comm B reply, DF=20, 21, whose MB field contains an RA Report with information previously provided to the transponder by the TCAS equipment.

(**1.36**) In RTCA DO-181D, in section §2.2.23.1.2, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, in the *Notes* of bullets "a" and "b" make the following changes:

a. Airborne Position Squitter. The airborne position Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 05_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR equals 16, DI equals 3 or 7 and RRS equals 5 will cause the resulting reply to contain the airborne position report in its MB field.*

b. Surface Position Squitter. The surface position Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 06_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR equals 16, DI equals 3 or 7 and RRS equals 6 will cause the resulting reply to contain the surface position report in its MB field.*

(**1.37**) In RTCA DO-181D, in section §2.2.23.1.2, in order to retain consistency with the terminology used in the ADS-B MOPS and ICAO SARPs, in existing bullet "c" change references to the aircraft identification squitter as follows. In order to adjust the requirements to account for Comm-B extraction using DI=3 or 7, as suggested in Working Paper SC209-WP11-09R1, in the Note of bullets "c" and "b" make the following change.

c. Aircraft Identification and Category Squitter. The aircraft identification and category Extended Squitter **shall** use format DF=17 with the contents of ground-initiated Comm-B Register 08_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR equals 16, DI equals 3 or 7 and RRS equals 8 will cause the resulting reply to contain the aircraft identification and category report in its MB field.*

(**1.38**) In RTCA DO-181D, in section §2.2.23.1.2, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, in the *Note* of bullet "d" make the following change:

d. Airborne Velocity Squitter. The airborne velocity Extended Squitter **shall** use format DF=17 with the contents of GICB Register 09_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS equals 9 will cause the resulting reply to contain the airborne velocity report in its MB field.*

(**1.39**) In RTCA DO-181D, in section §2.2.23.1.2, as identified in Working Paper SC209-WP11-19, insert new bullets "e" and "f" to define the Target State and Status, and the Aircraft Operational Status Messages as Periodic Status Messages and not included any further as "Event-Driven" Messages. Re-label the old bullet "e" for the Event-driven squitter, to become bullet "g." In order to adjust the requirements to account for Comm-B extraction using DI=3 or 7, as suggested in Working Paper SC209-WP11-09R1, in the *Notes* of bullets "e," "f" and "g" make the following change.

e. Target State and Status. The airborne Target State and Status Extended Squitter **shall** use format DF=17 with the contents of GICB Register 62_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=22 (e.g., BDS1=6), DI=3 or 7 and RRS=2 (e.g., BDS2=2) will cause the resulting reply to contain the airborne Target State and Status report in its MB field.*

f. Aircraft Operational Status. The airborne or surface Aircraft Operational Status Extended Squitter **shall** use format DF=17 with the contents of GICB Register 65_{16} inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=22 (e.g., BDS1=6), DI=3 or 7 and RRS=5 (e.g., BDS2=5) will cause the resulting reply to contain the Aircraft Operational Status report in its MB field.*

g. Event-driven Squitter. The event-driven Extended Squitter **shall** use format DF=17 with the contents of GICB Register $0A_{16}$ inserted in the ME field.

Note: *A GICB request (see §2.2.19.1.12.3) containing RR=16, DI=3 or 7 and RRS=0A will cause the resulting reply to contain the event-driven report in its MB field. Since multiple Register contents can be multiplexed through Register 61_{16} and $0A_{16}$, GICB extractions of these Registers is not recommended as the reply could be indeterminate.*

(**1.40**) In RTCA DO-181D, in section §2.2.23.1.3, in order to harmonize this section with the requirements specified in RTCA DO-181D, §2.2.23.1.3, replace existing bullet "a" with the following:

a. Initialization. At power up initialization, the transponder **shall** commence operation in a mode in which it broadcasts only acquisition squitters (see §2.2.18.2.6). The transponder **shall** initiate the broadcast of Extended Squitters for airborne position, surface position, airborne velocity, target state and status, aircraft operational status and aircraft identification and category when data are inserted into GICB Registers 05_{16}, 06_{16}, 09_{16}, 62_{16}, 65_{16} and 08_{16} respectively. This determination **shall** be made individually for each squitter type. The insertion of altitude data into Register 05_{16} by the transponder (see §2.2.23.1.8) **shall not** satisfy the minimum requirement for broadcast of the airborne position squitter.

Note 1: *This suppresses the transmission of Extended Squitters from aircraft that are unable to report position, velocity or identity information.*

If input to ~~the~~ register 05_{16} and 06_{16} ~~for a squitter type~~ stops for 60 seconds, broadcast of that Extended Squitter type will be discontinued until data insertion is resumed. The insertion of altitude by the transponder shall satisfy the minimum requirement for continuing to broadcast the airborne position squitter. After timeout (see §2.2.23.1.4.2), this squitter type may contain an ME field of ALL ZEROs.

Note 2: *Continued transmission for 60 seconds is required so that receiving aircraft will know that the data source for the message has been lost.*

When Extended Squitters are broadcast, transmission rates shall be as indicated in the following paragraphs. Acquisition squitters shall be reported in addition to Extended Squitters as specified in §2.2.18.2.6.c. Acquisition squitters shall always be reported if no Extended Squitters are reported.

(**1.41**) In RTCA DO-181D, in section §2.2.23.1.3, as identified in Working Paper SC209-WP11-19, in order to establish transmission rates for the Periodic Status Messages, insert new bullets "f" and "g" to define the Target State and Status, and the Aircraft Operational Status squitters, which are not included any further as "Event-Driven" squitters. Re-label the old bullets "f" and "g" to become bullets "h" (Event-Driven Squitter Rate) and "i" (Delayed Transmission) In existing bullets "b," "c," "d," and "e" at the end of each subparagraph, and in the existing paragraph for "Event-Driven Squitter Rate," change the reference for subparagraph "g" to subparagraph "i."

f. Airborne Target State and Status Squitter Rate. Airborne Target State and Status squitter **shall** be transmitted at rates as specified in §2.2.3.3.1.4.1 of RTCA DO-260B / EUROCAE ED-102A.

Verification of the transmission rates of Airborne Target State and Status Messages **shall** be performed in accordance with §2.4.3.3.1.4.1 of RTCA DO-260B / EUROCAE ED-102A.

g. Aircraft Operational Status Squitter Rate. The Aircraft Operational Status squitter **shall** be transmitted at the rates as specified in §2.2.3.3.1.4.2 of RTCA DO-260B / EUROCAE ED-102A, with the exceptions as specified in subparagraph "i." When transmitting the surface formats, the rate depends on whether the high or low squitter rate has been selected (see §2.2.23.1.6).

Verification of the transmission rates of Aircraft Operational Status Messages **shall** be performed in accordance with §2.4.3.3.1.4.2 of RTCA DO-260B / EUROCAE ED-102A.

(**1.42**) In RTCA DO-181D, in section §2.2.23.1.4.2, as partially modified in Working Paper SC209-WP11-19, it was proposed therein to replace the entire section with the edited text in the Working Paper. During Meeting #14 as discussed in the final review and comment resolution, and documented in the comment matrix in Working Paper SC209-WP14-06R1, and Working Paper SC209-WP14-08, it was agreed that the entire section would be replaced with the following:

2.2.23.1.4.2 Register Timeout and Termination

2.2.23.1.4.2.1 Timeout of Extended Squitter Messages

a. Timeout of Extended Squitter Messages shall be performed in accordance with §2.2.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A.

b. Verification of Extended Squitter Message timeout functions shall be performed in accordance with §2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A.

2.2.23.1.4.2.2 Termination of Extended Squitter Messages

a. Termination of Extended Squitter Messages shall be performed in accordance with §2.2.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A.

b. Verification of Extended Squitter Message termination functions shall be performed in accordance with §2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A.

(**1.43**) In RTCA DO-181D, in section §2.2.23.1.5.1, replace the paragraph with the following:

The criteria for selection of airborne or surface formats are contained in the latest version of §2.2.3.2.1.2 of RTCA/DO-260~~A~~B / EUROCAE ED-102A,

(**1.44**) In RTCA DO-181D, in section §2.2.23.1.5.2, in order to clarify the use of the TCS command to control Extended Squitter broadcasts, as identified in Working Paper SC209-WP11-12R1, make the following edits to the entire section as follows:

Aircraft without such automatic means **shall** report the airborne type ~~message~~ formats. Aircraft with or without such automatic on-the-ground determination **shall** ~~use position message types~~ report the surface type formats as commanded by control codes in the TCS subfield (see §2.2.23.1.7). After timeout of the TCS commands, control of airborne/ surface type formats **shall** revert to the means described above.

Note 1: *Extended squitter ground stations determine aircraft airborne or on-the-ground state by monitoring aircraft position, altitude and ground speed. Aircraft determined to be on-the-ground that are not reporting the surface ~~position message~~ type formats may be commanded to report the surface type formats via the TCS subfield. The normal return to the airborne ~~position messages~~ type formats is via a ground command to report the airborne type ~~message~~ formats. To guard against loss of communications after takeoff, commands to report the surface ~~position message~~ type formats automatically timeout.*

When commanded to report the surface type format by TCS commands, aircraft without automatic means of determining the on-the-ground condition, and aircraft with such means that are reporting airborne state, shall transmit acquisition squitters as specified in §2.2.18.2.6.a.

Note 2: *Transmission of the acquisition squitter will provide for TCAS acquisition in the event that an airborne aircraft is commanded to report the surface type formats. In this case, the CA field of the acquisition and Extended Squitters will continue to show that the aircraft is airborne, or is unable to determine its on-the-ground state.*

(**1.45**) In RTCA DO-181D, in section §2.2.23.1.7, as specified in Working Paper SC209-WP11-12R1, in order to provide ground control to inhibit ATCRBS and Mode S All-Call replies primarily for aircraft without a squat switch, replace the entire section 2.2.23.1.7 as follows:

2.2.23.1.7 Subfields in SD for Extended Squitter

The SD field contains the following information if the DI code is 2:

2.2.23.1.7.1 Type Control Subfield (TCS) in SD for Extended Squitter

TCS, the 3-bit (bits 21 – 23) Type Control Subfield in SD **shall** control the ~~position~~ extended squitter airborne and surface format types reported by the transponder, and its response to ATCRBS, ATCRBS/Mode S All-Call and Mode S-Only All-Call interrogations. These commands **shall** only affect the format types reported, they **shall not** change the aircraft determination of its on-the-ground condition. The commands for codes 1 and 2 **shall** be able to refreshed for a new period before timeout of the prior period.

Note 1: *Thus aircraft without the means to set the on-the-ground condition will continue to report code 6 in the CA field, and an aircraft with the means to set the on-the-ground condition that has determined that it is in the airborne state will continue to set code 5, independent of the Extended Squitter format that is emitted.*

The following TCS codes have been assigned:

TCS Codes	Description
0	No ~~position~~ surface format types or reply inhibit command
1	~~Use surface position type for the next 15 seconds~~ See §2.2.23.1.7.1.1
2	~~Use surface position type for the next 60 seconds~~ See §2.2.23.1.7.1.2
3	Cancel surface format types and reply inhibit commands
4 – 7	~~Not assigned~~ Reserved

2.2.23.1.7.1.1 TCS Equal to ONE (1)

(a) Broadcast extended squitter surface formats, including the Surface Position Message, the ID and Category Message, the Aircraft Operational Status Message and the Aircraft Status Message for the next 15 seconds at the appropriate rates (see Table 2-79 in RTCA DO-260B / EUROCAE ED-102A).
(b) Inhibiting replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations for the next 15 seconds.
(c) Broadcast acquisition squitters as per §2.2.18.2.6.c and Table 2-2.
(d) Make no change to the air/ground state reported via the CA, FS and VS fields.
(e) Discontinue broadcast of airborne message formats.
(f) Broadcast the surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

2.2.23.1.7.1.2 TCS Equal to TWO (2)

(a) Broadcast extended squitter surface formats, including the Surface Position Message, the ID and Category Message, the Aircraft Operational Status Message and the Aircraft Status Message for the next 60 seconds at the appropriate rates (see Table 2-79 in RTCA DO-260B / EUROCAE ED-102A).
(b) Inhibiting replies to ATCRBS, ATCRBS/Mode S All-Call and Mode S-only All-Call interrogations for the next 60 seconds.
(c) Broadcast acquisition squitters as per §2.2.18.2.6.c and Table 2-2.
(d) Make no change to the air/ground state reported via the CA, FS and VS fields.
(e) Discontinue broadcast of airborne message formats.
(f) Broadcast the surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

2.2.23.1.7.2 Rate Control Subfield (RCS) in SD for Extended Squitter

RCS, the 3-bit (bits 24 – 26) Rate Control Subfield in SD **shall** control the squitter rate of the transponder when it is reporting the Extended Squitter surface type formats. This subfield **shall** have no effect on the transponder squitter rate when it is reporting the airborne ~~position~~ type formats ~~of Extended Squitter~~.

Note 2: *Aircraft without the means of determining on-the-ground state or aircraft with such means that are declaring the airborne state must be commanded to transmit the surface format (via TCS) before they can be controlled by this subfield. Both of these commands may be sent in the same interrogation.*

Note 3: *Both TCS and RCS have specific timeout periods. If the surface format command times out first, the aircraft will resume broadcasting the airborne format (unless it is now declaring the on-the-ground state or the surface format is selected in accordance with the requirements of §2.2.3.2.1.2 (3) of RTCA DO-260B /EUROCAE ED-102A) even if the squitter suppression command has not timed out (since the squitter suppression command has no effect on the transmission of the airborne format). If the squitter suppression command times out first, the aircraft will resume the transmission of surface ~~squitters~~ formats.*

The following RCS codes have been assigned:

RCS Codes	Description
0	No surface Extended squitter rate command
1	Report high surface Extended squitter rate for 60 seconds
2	Report low surface Extended squitter rate for 60 seconds
3	Suppress all surface Extended squitters for 60 seconds
4	Suppress all surface Extended squitters for 120 seconds
5 – 7	~~Not assigned~~ Reserved

Note 4: *The definition of high and low squitter rate is given in §2.2.23.1.3 and applies to the Surface Position, Aircraft Identification and Category, and the Operational Status Messages.*

Note 5: *As stated in §2.2.18.2.6.b.4, Acquisition squitters are transmitted when Surface Extended Squitters are suppressed by using RCS=3 or 4.*

2.2.23.1.7.3 Surface Antenna Subfield (SAS) in SD for Extended Squitter

SAS, the two bit (bits 27 – 28) Surface Antenna Subfield in SD **shall** control the selection of the diversity antenna that is used for: (1) the Extended Squitter when it is reporting the surface type formats, and (2) the acquisition squitter when the aircraft is reporting the on-the-ground condition. This subfield **shall** have no effect on the transponder diversity antenna selection when the aircraft is reporting the airborne status type, or if the aircraft does not have diversity antennas. When reporting the surface type formats, the default **shall** be the top antenna. The following SAS codes have been assigned:

SAS Codes	Description
0	No antenna command
1	Alternate top and bottom antennas for 120 seconds
2	Use bottom antenna for 120 seconds
3	Return to the default

(**1.46**) In RTCA DO-181D, in section §2.2.23.1.8 there is an incorrect paragraph reference that must be corrected just below the SSS table. Correct the reference in the first sentence as:

"ACS, the 12-bit (bits 41 - 52) Altitude Code Subfield in ME **shall** (under control of the ATS subfield, §2.2.23.1.9)

(**1.47**) In RTCA DO-181D. in section §2.2.23.2, since the Target State and Status and the Aircraft Operational Status Messages have been moved out from under the Event-Drive protocol, replace this section with the following:

The Event-Driven Squitter is broadcast each time data is loaded into GICB Register $0A_{16}$ as specified in §2.2.23.1.3. The transponder also makes available GICB Registers related to the Extended Squitter Event-Driven Squitter. The transponder shall provide data to the appropriate GICB Registers that are loaded into the Event-Driven GICB Register $0A_{16}$. The following GICB Register~~s are~~ is currently defined for the Event-Driven Squitter:

BDS Code 6,1 Aircraft Status (Extended Squitter Emergency/Priority Status)
~~BDS Code 6,2 Target State and Status~~
~~BDS Code 6,5 Extended Squitter Aircraft Operational Status~~

Note: Additional information on the data content and transmission of these Extended Squitter Messages can be found in the latest version of RTCA DO-260B / EUROCAE ED-102A.

(**1.48**) In RTCA DO-181D. in section §2.2.23.4 in order to comply with the changes in transmission rates made in DO-260B/ED-102A for Event-Driven Messages, and the additional changes requested in Working Paper SC209-WP12-16R1, replace the paragraph and the *Note* below with the following:

The maximum total number of Extended Squitters (DF=17~~, 18 or 19~~) emitted by any Extended Squitter installation **shall not** exceed 6.2 per second averaged over any 60 second interval, except during an emergency condition.

Note: ~~*For installations capable of emitting DF=19 squitters, transmission rates for lower power DF=19 squitters are limited to a peak of 45 DF=19 squitters per second, and 35 DF=19 squitters per second averaged over 10 seconds, provided that the maximum total squitter power-rate product for the sum of full power DF=17 squitters, full power DF=19 squitters, and lower power DF=19 squitters, is maintained at or below a level equivalent to the power sum of 6.2 full power squitters per second averaged over 10 seconds. This low-power, higher squitter rate capability is intended for limited use by State aircraft in coordination with appropriate regulatory bodies.*~~ *For installations capable of emitting extended squitters other than DF=17, see ICAO Annex 10, Vol IV, §3.1.2.8.9.*

(**1.49**) In RTCA DO-181D, in section §2.2.24.c, the requirement required transponders to support TCAS/ACAS with Elementary Surveillance (ELS). During consideration of Final Review and Comment resolution in Meeting #14, it was agreed that the beginning of the paragraph would be changed as follows:

c. ~~In addition,~~ Optionally, the Mode S transponder must be capable of TCAS operation in accordance with all requirements defined in §2.2.22. In particular, the transponder reports ACAS capability and version in Register 10_{16} as well as the RA Report in Register 30_{16}.

(**1.50**) In RTCA DO-181D, in section §2.2.24.2.1, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, add sub-bullet "m" to the list of references mentioning the use of BDS2 with SI Code.

m. §2.2.19.1.12.2, "Extended Data Source Designators"

(**1.51**) In RTCA DO-181D, in section §2.2.24.3.2.2, in order to account for the changes that are being made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent equivalent changes in ICAO Doc 9871, Edition 2, the Mode S Subnetwork Version Number will have to change accordingly. Replace Table 2-4, and the sentence below it with the following:

Version Number	ICAO	RTCA	EUROCAE
0	Mode S Subnetwork Not Available		
1	ICAO Doc 9688 (1996)		
2	ICAO Doc 9688 (1998)		
3	ICAO Annex 10, Vol III, Amendment 77		
4	ICAO Doc 9871, Edition 1	DO-181D	ED-73C
5	ICAO Doc 9871, Edition 2	DO-181E	ED-73E
6–127	~~Unassigned~~ Reserved		

To be consistent with Elementary and Enhance Surveillance requirements (e.g., this version of these MOPS), the Mode S Subnetwork Version Number shall be set to "~~3~~5" or "higher".

(**1.52**) In RTCA DO-181D, there are numerous occasions where the phrase "Minimum Update Interval" has been incorrectly used, and where the phrase "Maximum Update Interval" should have been used instead. In the requirements description at some of these locations, reference has also been made to the Register Allocation Table in Appendix B, which is incorrectly referenced as Table B-1, and should have been referenced as Table B-2-1. In each of the following paragraph references, **all instances of** "Minimum Update Interval" **must be changed to** "Maximum Update Interval," and **where references occur** to "Table B-1," **they must be changed to** "Table B-2-1."

§2.2.24.3.3	§2.2.25.1.3	§2.2.25.6.3	§2.7.1.3
§2.2.24.5.3	§2.2.25.2.2.7	§2.2.25.7.3	§2.7.2.2.7
§2.2.24.6.3	§2.2.25.3.3	§2.2.25.8.3	§2.7.3.3
§2.2.24.7.3	§2.2.25.5.3	§2.2.26.3	§2.8.3

(**1.53**) In RTCA DO-181D, in section §2.2.24.6.2.1, delete the following *Note* after the initial introductory sentence and just prior to bullet "a," in order to avoid possible confusion regarding the usage of Register 08_{16}.

~~***Note:*** *Aircraft Registration Data may also be used in Register* 08_{16} *when Extended Squitter is implemented. As such, the requirements inferred below will also apply to Register* 08_{16} *when Extended Squitter is implemented.*~~

(**1.54**) In RTCA DO-181D, in section §2.2.24.6.2.1.b, to correct a minor typographical error, in the *Note* following subparagraph "b":

Replace "(Datal Link Capability Report)" **with** "(Data Link Capability Report)"

(**1.55**) In RTCA DO-181D, in section §2.2.24.6.2.1.d, to correct a minor typographical error in bullet (3) of subparagraph "d":

Replace the word "conatain" **with** "contain"

(**1.56**) In RTCA DO-181D, in section §2.2.24.6.3.b, correct a minor typographical error by deleting the second use of the word "of."

(1). The contents of ~~of~~ the character field of Register 20_{16} shall be set to ZERO (0).

(**1.57**) In RTCA DO-181D, in section §2.2.24.6.4.2, in order to correct a cut-and-paste error in a bit reference, replace the only sentence in the section with the following correction:

"Correct servicing of the character fields of Register 20_{16} **shall** be reported in Register 17_{16} via bit ~~33~~ 7 as defined in §2.2.24.4.2.1."

(**1.58**) In RTCA DO-181D, in section §2.2.25, in order to add the barometric pressure setting as a downlink aircraft parameter, as agreed in Working Paper SC209-WP12-21, make the following changes:

The Enhanced Surveillance application entails the use of ~~eight~~ the following Downlink Aircraft Parameters (DAPs) ~~for initial implementation, as follows~~:

a. Magnetic Heading
b. Indicated Airspeed and/or Mach No.
c. Vertical Rate (climb/descend)
d. MCP/FCU Selected Altitude
e. Ground Speed
f. Roll Angle
g. Track Angle Rate (or True Airspeed if Track Angle Rate is not available)
h. True Track Angle
i. Barometric Pressure Setting

(**1.59**) In RTCA DO-181D, in section §2.2.25.5.2.5, as agreed to in Working Paper SC209-WP12-04, indicate that all of the Reserved bits in Register 40_{16} shall be set to ZERO (0). Make the following changes in the title and the text.

2.2.25.5.2.5 Reserved Bits (40 to 47, 52 and 53)

Bits 40 to 47, 52 and 53 of Register 40_{16} "MB" field shall be set to ZERO (0).

(**1.60**) In RTCA DO-181D, in section §2.2.25.7.3.c, as indicated in Working Paper SC209-WP11-10R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49, update the maximum update interval in subparagraph "c" to 2.0 seconds as below:

c) If a particular data field in Register $5F_{16}$ cannot be updated within ~~1~~2.0 seconds (~~e.g~~i.e., the greater of 2.0 seconds or twice the specified ~~minimum~~ maximum update interval of 0.5 seconds), then the data field shall be ZEROed (i.e., binary "00").

(**1.61**) In RTCA DO-181D, in section §2.2.25.8.3, in order to correct references to the "maximum update interval" as detailed in Appendix B, Table B-2-1, and to also correct the specific maximum update interval for Register 60_{16}, which is specified in Table B-2-1 as 1.3 seconds, make the changes identified below in yellow to replace the word "minimum" with the word "maximum," and replace the actual values for the Register 60_{16} maximum update interval as indicated:

a. The maximum update interval at which Register 60_{16} **shall** be reloaded with valid data is 1.3 seconds.

   Note: *Register 60_{16} is updated at least once every 1.3 seconds.*

b. The time between availability of data that causes a change in Register 60_{16} and the time that the change is made to Register 60_{16} **shall** be less than the maximum update interval specified as 1.3 seconds.

c. If Magnetic Heading data in Register 60_{16} "MB" field bits 2 through 12 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 1 shall be set to ZERO (0) and bits 2 through 12 **shall** be set to ZERO (0).

d. If Indicated Airspeed data in Register 60_{16} "MB" field bits 14 through 23 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 13 shall be set to ZERO (0) and bits 14 through 23 **shall** be set to ZERO (0).

e. If Mach data in Register 60_{16} "MB" field bits 25 through 34 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 24 shall be set to ZERO (0) and bits 25 through 34 **shall** be set to ZERO (0).

f. If Barometric Altitude Rate data in Register 60_{16} "MB" field bits 36 through 45 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 35 **shall** be set to ZERO (0) and bits 36 through 45 shall be set to ZERO (0).

g. If Inertial Vertical Rate data in Register 60_{16} "MB" field bits 47 through 56 cannot be updated with valid data within 2.6 seconds (e.g., twice the specified maximum update interval of 1.3 seconds) then Status Bit 46 **shall** be set to ZERO (0) and bits 47 through 56 shall be set to ZERO (0).

(**1.62**) In RTCA DO-181D, in section §2.2.26.2.1, as agreed to in Working Paper SC209-WP12-04, add sub-bullets "f" and "g" just prior to *Note #1*, to indicate that generic data bits "y" will be set to ZERO if the status bit is set to ZERO, and that any Reserved bits will be set to ZERO.

f. The data bits of field "y" will be set to ZERO if the Status Bit is set to ZERO.

g. Any Reserved Bits will be set to ZERO.

(**1.63**) In RTCA DO-181D, in section §2.2.26.3, in order to correct references to the "maximum update interval" as detailed in Appendix B, Table B-2-1, and to also correct the specific references to the actual Table in Appendix B, make the changes identified below in yellow to replace the word "minimum" with the word "maximum," and replace the Table reference with "Table B-2-1" as indicated below:

a. The maximum update interval at which a data field in a Register will be reloaded with valid data is defined for each register in Table B-2-1 in Appendix B.

b. The transponder will load valid data into the related transponder Register as soon as it becomes available at the Mode S Specific Services entity.

c. The time between availability of data that causes a change in a data-field of a Register and the time that the change is made to the Register will be less than the maximum update interval specified in Table B-2-1 in Appendix B.

d. If a data-field field cannot be updated with valid data within twice the specified maximum update interval defined for the Register, or 2 seconds (whichever is the greater), then the Status Bit (if specified) of the field will be set to ZERO (0) (INVALID) and that data field will be ZEROed.

(**1.64**) In RTCA DO-181D, in section §2.3.2.5, as originally discussed in Working Paper SC209-WP11-10R1, and as further detailed in Working Paper SC209-WP12-17R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49, make the following addition to the end of Step 1:

Step 1 Pulse Level Tolerances, ATCRBS/Mode S All-Call (§2.2.6.1.1)
Connect the equipment as shown in Figure 2-31. Interrogate at the standard rate and at an input level 10 dB above MTL. Use an ATCRBS Mode A interrogation followed by a 1.6-microsecond P4 pulse in its nominal position. Vary the level of the P4 pulse between -10 and 0 dB in 1 dB steps with respect to P3. Verify the changeover from ATCRBS to Mode S replies at the relative P4 levels specified in §2.2.6.1.1.a and §2.2.6.1.1.b when more than 90% of the replies are Mode S or ATCRBS.

(**1.65**) In RTCA DO-181D, in section §2.4.2.5, as originally discussed in Working Paper SC209-WP11-10R1, and as further detailed in Working Paper SC209-WP12-17R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49, make the following addition to the end of the first paragraph in Step 1:

Step 1 Pulse Level Tolerances, ATCRBS/Mode S All-Call (§2.2.6.1.1)
Connect the equipment as shown in Figure 2-31. Interrogate at the standard rate and at an input level 10 dB above MTL. Use an ATCRBS Mode A interrogation followed by a 1.6-microsecond P4 pulse in its nominal position. Vary the level of the P4 pulse between -10 and 0 dB in 1 dB steps with respect to P3. Verify the

changeover from ATCRBS to Mode S replies at the relative P4 levels specified in §2.2.6.1.1.a and §2.2.6.1.1.b when more than 90% of the replies are Mode S or ATCRBS.

(**1.66**) In RTCA DO-181D, in section §2.4.2.6, in order to correct references to "All-Calls" and to harmonize between DO-181D and EUROCAE ED-73C, for Step 4 of this test procedure, make the following changes in the title and the third paragraph:

Step 4 Recovery from a Suppression Pair or ATCRBS-Only All-Calls or Unaccepted ATCRBS/Mode S ~~or ATCRBS-Only~~ All-Calls (§2.2.7.2.2 and §2.2.7.2.4)

1st paragraph unchanged
2nd paragraph unchanged

Lock out transponder to All-Calls (non-selective) and repeat procedure with ~~P_4-type~~ ATCRBS/Mode S All-Call interrogations in place of the suppression pair. Set the II field of the Mode S-Only All-Call to a value other than ZERO (0) so that it will not be affected by the lock-out condition.

(**1.67**) In RTCA DO-181D, in section §2.4.2.6, as originally discussed in Working Paper SC209-WP11-10R1, and as further detailed in Working Paper SC209-WP12-17R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49 during Meeting #12, make the following changes to the last two (2) paragraphs in each of the sub-steps of the test procedures Step 7A through Step 7H:

Turn off the Slave Test Set. Do not reset the transponder.

Set the Master Test Set to generate a standard (i.e., -60 dBm) UF4, UF5, Mode A and Mode C interrogations and verify that the ATCRBS Mode A code and Altitude/ Mode C information provided in the transponder replies is correct.

Repeat the entire procedure given in ~~preceding paragraphs~~ this Step as needed to verify performance of the transponder on both top and bottom channels of diversity transponder.

(**1.68**) In RTCA DO-181D, in section §2.4.2.6, as originally discussed in Working Paper SC209-WP11-10R1, and as further detailed in Working Paper SC209-WP12-17R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49 during Meeting #12, make the following changes to the second (and last) subparagraph in Step 7I:

Repeat the procedure with the Master Test Set using Mode A/C/S All-Call interrogations while locking-out the transponder to these All Call interrogations in place of suppression pair. Verify that the delay time is less than or equal to 15 microseconds after the P_4 pulse.

Repeat the procedure in the preceding paragraph with the Master Test Set using Mode A/C-only All-Call interrogations in place of suppression pair.

(**1.69**) In RTCA DO-181D, in section §2.4.2.7, as indicated in Working Paper SC209-WP11-10R1, following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49, make the following changes to the *Note* immediately following the text of the Step 6 subparagraph:

Note: The purpose of this test is to demonstrate that when the interference pulse combines with the P1 pulse of the P1-P2 pair of a Mode S interrogation, that the transponder ~~detects the ATCRBS All-Call and~~ does not reply with a ATCRBS reply.

(**1.70**) In RTCA DO-181D, in section §2.5.4.1, in order to clarify that different types of modulators could be used to generate the phase reversal and that a diode detector can only be used for test purposes as described in Working Paper SC209-WP12-15R2, make the following changes to the “Equipment Required” section:

Equipment Required:
Test set capable of generating Mode S interrogations at a 0-dBm power level.

DPSK modulation detector ~~(a simple diode detector is adequate for manual determination of the location of phase reversals in a 0-dBm signal)~~. Use a simple diode detector for manual determination of the location of phase reversals when the Mode S signal test generator is using hard keying with amplitude drop.

Note: *Such a method is only possible for test purposes as some transmitters can generate the phase reversal using IQ modulator with little or no amplitude drop.*

Wide-band oscilloscope (HP1710B, or equivalent).

………………………..

Verification of Test Set Error Protection Circuits
When the Mode S signal generator uses a hard keying method to generate phase reversal resulting in amplitude drop, the following method can be used to verify the Test Set Error Protection circuit.

(**1.71**) In RTCA DO-181D, in section §2.5.4.6.2.1, during Meeting #14 as discussed in the final review and comment resolution, and documented in the comment matrix in Working Paper SC209-WP14-06R1, and Working Paper SC209-WP14-08, it was agreed that the entire section would be replaced as follows:

a. Verify Extended Squitter Message Rate and Timeout functions by demonstrating successful completion of all test procedures called out in §2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A, as required by §2.2.23.1.4.2.1.

Note: *§2.4.3.3.2.11 of RTCA DO-260B / EUROCAE ED-102A indicates that ADS-B Message Timeout performance is tested in §2.4.3.3.2.2 through §2.4.3.3.2.8.2. These same test procedure sections verify the Message Rate in RTCA DO-260B / EUROCAE ED-102A.*

b. Verify Extended Squitter Message Rate and Termination functions by demonstrating successful completion of all test procedures called out in §2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A, as required by §2.2.23.1.4.2.2.

Note: *§2.4.3.3.2.12 of RTCA DO-260B / EUROCAE ED-102A indicates that ADS-B Message Termination performance is tested in §2.4.3.3.2 through §2.4.3.3.2.8.2. These same test procedure sections verify the Message Rate in RTCA DO-260B / EUROCAE ED-102A.*

c. While performing the test procedures specified in subparagraphs "a" and "b" above, verify the content of the CA, AA and PI fields in the Extended Squitter Messages.

d. For diversity transponders, setup the transponder to transmit airborne format Extended Squitters. Verify that each Extended Squitter type identified in §2.2.23.1.2 occur alternately from both channels. For transponders that are designed for aircraft installations with automatic means of determining on-the-ground condition, set the transponder to on-the-ground status and verify that Extended Squitters occur on the top antenna only at the prescribed rates.

(**1.72**) In RTCA DO-181D, in section §2.5.4.6.2.2, replace the second paragraph with the following:

Verify the content of the CA, AA and PI fields of all Extended Squitter replies. For the following test, connect the transponder to the appropriate source that provides altitude code input to the transponder. Also, as required, setup to provide Extended Squitter data to ground initiated Comm-B Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, 09_{16} , ~~and~~ $0A_{16}$, 62_{16} and 65_{16} through an external interface as specified in §2.2.13.2.

(**1.73**) In RTCA DO-181D, in section §2.5.4.3, as originally discussed in Working Paper SC209-WP11-10R1, and following a review of EUROCAE ED-73C by EADS, and discussion and agreement by RTCA SC-209 and EUROCAE WG-49, replace the entire test Procedure #3 as detailed in Working Paper SC209-WP12-17R1.

(**1.74**) In RTCA DO-181D, in sections §2.5.4.4.1 and §2.5.4.4.2, as specified in Working Paper SC209-WP13-03R1, make the identified changes in order to clarify that the transponder should interpret multisite lockout in an interrogation where DI=1, 7 and non-selective lockout in the same interrogation where PC=1, and set the T_D and appropriate T_L timers accordingly from that single interrogation. Changes include adding interpretation of PC=0, 1 in an interrogation where DI=3 to support SI lockout and non-selective lockout in a single interrogation.

(**1.75**) In RTCA DO-181D, in section §2.5.4.5, as specified in Working Paper SC209-WP13-03R1, make the identified changes in order to clarify that the transponder should interpret multisite lockout in an interrogation where DI=1, 7 and non-selective lockout in the same interrogation where PC=1, and set the T_D and appropriate T_L timers accordingly from that single interrogation. Changes include adding interpretation of PC=0, 1 in an interrogation where DI=3 to support SI lockout and non-selective lockout in a single interrogation.

(**1.76**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 3, make the following changes in the first three lines of the test procedure:

Step 3 Provide Extended Squitter updates to the transponder at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, ~~and~~ 09_{16}, 62_{16} and 65_{16}.

(**1.77**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 4, make the following changes:

Step 4 Set up the transponder as in Step 3 with Extended Squitter updates to the transponder at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1. Place the transponder in the airborne state. Stop updates of all Extended

Squitter data, except altitude information, to the transponder for GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16}, ~~and~~ 09_{16}, 62_{16} and 65_{16}.

a. Verify that after 2 seconds, ~~all subsequent~~ the Extended Squitter ME fields for ~~(~~GICB Register~~s~~ 05~~7~~$_{16}$, ~~and 09$_{16}$)~~ are ZERO with the exception of the ACS and surveillance status field~~s~~ ~~in the airborne position squitter (GICB Register 05$_{16}$) and the airborne identification squitter (GICB Register 08$_{16}$)~~.

b. Verify that after 2 seconds the aircraft identification and category squitter (GICB Register 08_{16}) continues to be transmitted.

c. Verify that after 2 seconds only the Selected Altitude, Selected Heading or Barometric Pressure Setting subfields of the target state and status squitter (GICB Register 62_{16}) are set to ZERO. Verify that the remaining Extended Squitter ME subfields are not cleared, as they contain other integrity, mode or status information.

d. Verify that after 2 seconds the Extended Squitter ME fields of the aircraft operational status squitter (GICB Register 65_{16}) are not cleared, as they contain various integrity, mode or status information.

e. Verify that after 2.6 seconds the Extended Squitter ME fields of the airborne velocity squitter (GICB Register 09_{16}) are cleared, and verify that it is not being transmitted.

f. Place the transponder in the ground state and verify that the surface position Extended Squitter ME field (GICB Register 06_{16}) is ZERO. Repeat the setup as in Step 3 with Extended Squitter updates to the transponder at a one half second rate. Place the transponder in the airborne state. Interrogate the transponder with RR=17 and DI=7 and verify that the SCS subfield of the data link capability report is one. After all updates (except altitude information) have ceased for 10 seconds, interrogate to extract the data link capability report and verify that the SCS subfield is ZERO. Interrogate the transponder with ground initiated Comm-B requests with RR=16, DI=7 and RRS=5, 6, 7, 8 and 9 respectively. Verify that the MB fields are ZERO with the exception of the ACS field in the airborne position squitter (GICB Register 05_{16}) and the airborne identification squitter (GICB Register 08_{16}). After all updates (except altitude information) have ceased for 60 seconds, verify that airborne identification and category ~~and airborne velocity~~ Extended Squitters are ~~no longer~~ still being transmitted. Place the transponder in the ground state and verify that the surface position Extended Squitter (GICB Register 06_{16}) is no longer transmitted. Return the transponder to the airborne state. Verify that the acquisition squitter and airborne position squitter are broadcast. Set the ALT switch to the "off" position. Verify that the ME field of the airborne position squitter is ZERO. After 60 seconds, verify that the transponder no longer broadcasts airborne position squitters.

(**1.78**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 5, make the following changes in the first three lines of the test procedure:

Step 5 Set the ALT switch to the "on" position and provide altitude code input to the transponder. Provide Extended Squitter updates to the transponder at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1.

(**1.79**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 6, in order to consolidate several changes as identified in Working Paper SC209-WP12-05R1, and to be clear about the timeout requirements for Register 08_{16}, make the following changes:

Step 6 Set the ALT switch to the "on" position and provide altitude code input to the transponder. Provide Extended Squitter updates to the transponder at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 07_{16}, 08_{16} and 09_{16}. Verify that the ME fields of the airborne position, velocity and aircraft identification squitters match the data input. Stop updates of Extended Squitter data to the transponder for GICB Registers 08_{16} and 09_{16} only. After 15 seconds, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping updates to GICB Register 08_{16}. After 2.6 seconds, verify that the ~~ME field of the~~ airborne velocity squitter is ~~ZERO~~ no longer transmitted. Interrogate with RR=16, DI=7 and RRS=5, 6, 8 and 9 and verify that the MB fields match the ME fields in the corresponding Extended Squitter reply. Specifically, verify that the MB and ME fields for Register 08_{16} continue to match the data input prior to stopping the updates to GICB Register 08_{16}. After 10 seconds, interrogate to extract the data link capability report and verify that SCS is one. After 60 seconds, verify that airborne position and aircraft identification squitters ~~reports~~ are still transmitted ~~and that aircraft identification and airborne velocity squitters are not transmitted~~. Specifically, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping the updates to GICB Register 08_{16}.

(**1.80**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 7, in order to consolidate several changes as identified in Working Paper SC209-WP12-05R1, and to be clear about the timeout requirements for Register 08_{16}, make the following changes:

Step 7 Configure the transponder to inhibit Acquisition squitters when Extended Squitters are broadcast. Prior to providing Extended Squitter updates, verify that Acquisition squitters are broadcast. Provide Extended Squitter updates at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1 to GICB Registers 05_{16}, 06_{16} and 08_{16} and provide altitude code input to the transponder. Verify that Extended Squitters are broadcast and Acquisition squitters are not broadcast. Verify that airborne position and aircraft identification squitters are broadcast at the proper rate and alternately on the top and bottom antenna ports as specified for airborne state if antenna diversity is supported. Additionally provide updates to GICB Register 09_{16}. Verify the broadcast of airborne position squitters, aircraft identification squitters and airborne velocity squitters at the proper rate and the ME data content matches the data stored in GICB Registers 05_{16}, 08_{16} and 09_{16}, respectively. Verify that the transponder does not broadcast Acquisition squitters.

Set the ALT switch to the "off" position and stop update to GICB Registers 05_{16}, 06_{16}, 08_{16} and 09_{16}. After 2 seconds, verify that the ME field~~s~~ of the airborne position ~~and airborne velocity~~ squitters are ZERO. After 2.6 seconds, verify that the airborne velocity squitter is no longer transmitted. Interrogate with UF=4, RR=16, DI=7 and RRS=5, 6, 8 and 9, respectively. Verify that the MB fields of the replies match the data of the corresponding Extended Squitter reply. Specifically, verify that the MB fields of the replies for Register 08_{16} continue to match the data that was provided prior to stopping the updates to GICB Register 08_{16}. After 60 seconds, verify that Extended Squitter airborne position and airborne velocity squitter transmissions stop. Verify that the aircraft identification Extended Squitter transmissions are continued and that the contents of the ME field matches the data that was provided prior to stopping the updates to GICB Register 08_{16}. ~~and~~ Verify that the transponder resumes Acquisition squitter broadcast.

Repeat above sequence except stop update to GICB Registers 05_{16} and 06_{16} only. After 2 seconds, verify that the ME field of the airborne position report is ZERO. After 60 seconds, verify that the transponder no longer broadcasts airborne position squitters and continues to broadcast airborne velocity and aircraft identification squitters. Verify that the transponder continues to inhibit the broadcast of Acquisition squitters.

Repeat above except stop update to GICB Register 09_{16} only. After 2.6 seconds, ~~Again,~~ verify that ~~after 2 seconds the ME field of~~ the airborne velocity squitter is ~~ZERO~~ no longer transmitted, and after 60 seconds, ~~both airborne velocity and~~ verify that the Acquisition squitters are not transmitted.

(**1.81**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 8, make the following changes:

Step 8 Provide data to the transponder to trigger data to be loaded into GICB Register $0A_{16}$. Verify that an Event-Driven Extended Squitter is generated with the proper data content. Repeat for all supported Event-Driven Extended Squitter Message types. ~~Event-Driven Extended Squitter Messages include BDS 6,1, BDS 6,2 and BDS 6,5: the Extended Squitter Aircraft Status, the Target State and Status, and the Aircraft Operational Status Messages, respectively~~. Verify that the data contained in the GICB Register corresponding to the Event-Driven Extended Squitter Message type matches the data contained in the transmitted Extended Squitter. Update GICB Register $0A_{16}$ at a rate less than twice every second. Verify that an Event-Driven Extended Squitter is generated subsequent to each update with the proper data content. Vary the data content provided externally to the transponder and verify that the data content subsequent to update of the Event-Driven report is correct. Increase the update rate to exceed twice per second. Verify that the

Event-Driven Extended Squitter rate does not exceed twice per second, and that the data content reflects the most recent update contents.

For the following steps, for those transponders that support automatic detection of on-the-ground status, change the transponder to on-the-ground status. Configure the transponder to not inhibit Acquisition squitters when Extended Squitters are broadcast.

(**1.82**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 9, make the following changes:

Step 9 Upon power-up initialization of the transponder, verify that the transponder broadcasts Acquisition squitters at the proper rate but does not broadcast Extended Squitters. For transponders that support automatic detection of on-the-ground status and diversity, verify that Acquisition squitters occur on the top antenna port only. Interrogate the transponder with GICB requests with RR=16, DI=7 and RRS=5, 6, 8 and 9 respectively. Verify that the MB field of the corresponding replies are ZERO, with the exception of Register 08_{16}.

(**1.83**) In RTCA DO-181D, in section §2.5.4.6.2.2, in Step 10, in order to consolidate several changes as identified in Working Paper SC209-WP12-05R1, and to be clear about the timeout requirements for Register 08_{16}, make the following changes:

Step 10 Provide Extended Squitter updates to the transponder at a ~~rate~~ maximum update interval as specified in Appendix B, Table B-2-1. Include updates to GICB Registers 05_{16}, 06_{16}, 08_{16} , ~~and~~ 09_{16} , 62_{16} and 65_{16}. Use other than ZERO or all ONEs for the surface position report and the aircraft identification report. Set TRS to ZERO. For transponders that support automatic on-the-ground detection, perform the following:

1. Verify that the transponder broadcasts surface position squitters at the high rate and the ME data content matches the data stored in GICB Register 06_{16}.
2. Verify that the transponder broadcasts aircraft identification squitters and that they occur uniformly over the range of 4.8 to 5.2 seconds as specified in §2.2.23.1.3.d. Verify that the ME data content matches the data stored in GICB Register 08_{16}.
3. Verify that the transponder broadcasts aircraft operational status squitters at the rates as specified in §2.2.3.3.1.4.2 of RTCA DO-260B / EUROCAE ED-102A and that the data content matches the data stored in GICB Register 65_{16}. When transmitting the surface formats, the rate depends on whether the high or low squitter rate has been selected (see §2.2.23.1.6).
4. Verify that the transponder does not broadcast the airborne position and the airborne velocity squitter.
5. Verify that the transponder does not broadcast Acquisition squitters.

6. Stop update of GICB Registers 05_{16}, 06_{16}, 08_{16}, ~~and~~ 09_{16} and 65_{16}. After 2 seconds, verify that the surface position squitter ME field is ZERO. After 15 seconds, verify that the ME field of the aircraft identification squitter continues to match the data input prior to stopping updates to GICB Register 08_{16}.
7. After 60 seconds, verify that surface position and surface aircraft operational status ~~identification~~ squitters stop. Verify that the aircraft identification extended squitter transmissions are continued and that the contents of the ME field matches the data that was provided prior to stopping the updates to GICB Register 08_{16}. ~~and~~ Verify that Acquisition squitter transmissions resume.

For transponders that do not support automatic on-the-ground detection, verify that airborne position squitters, airborne velocity squitters and aircraft identification squitters are transmitted at the proper rate and data content. Verify that surface position squitters are not emitted. Verify that the transponder broadcasts Acquisition squitters at the proper rate.

Repeat except vary the data content of GICB Registers 06_{16} and 08_{16} and verify the data content of each Extended Squitter subsequent to each register update.

(**1.84**) In RTCA DO-181D, in section §2.5.4.6.3, the test procedure for squitter control verification has been modified in order to account for the changes that were agreed to by RTCA SC-209 and EUROCAE WG-49 for the TCS and RCS commands. In Working Paper SC209-WP11-12R1 there were extensive changes made to have the TCS and RCS commands apply to all surface type messages and also to inhibit replies to ATCRBS and All-Call interrogations. Working Paper SC209-WP12-06R3 completely revises the test procedure in §2.5.4.6.3 to account for the previously agreed changes to TCS and RCS. These test procedures in §2.5.4.6.3 were revised again during the final comment resolution of Meeting #14 when it was agreed to revise the RCS command and remove the ability to suppress Extended Squitters as recorded in ICAO ASP TSG Working Paper TSGWP10-21R1.

(**1.85**) In RTCA /DO-181D, in section §2.5.4.7, as agreed to in Working Paper SC209-WP11-20R1, add the following new test procedures at the end of the current test procedure, and just prior to §2.5.4.8:

Alert when leaving standby condition

a. Set to the airborne state and change the input of the ID function to a value other than 7500, 7600 or 7700.
b. Wait 19 seconds.
c. Set the transponder to STANDBY condition.
d. Set the transponder to return to normal condition.
e. Verify that the Mode A Code, temporary alert is set (FS field value is 2 and SSS=2 when the transponder is ES capable) for 18 ±1 seconds after leaving the STANDBY condition.
f. Repeat Steps “a” through “e”, except in Step “c” set the transponder to OFF.

Change the input of the ID function to 7500

a. Set to the airborne state and set the transponder to STANDBY condition and provide the transponder with the 7500 code.
b. Set the transponder to return to normal condition.
c. Verify that the permanent alert is set (FS field value is 2 and SSS=1 when the transponder is ES capable).
d. Repeat the test with 7600 and 7700.
e. Repeats Steps “a” through “d”, except in Step “a” set the transponder to OFF.

(**1.86**) In RTCA DO-181D, in section §2.5.4.13, in order to correct references to “All-Calls” and to harmonize between DO-181D and EUROCAE ED-73C, make the following change to the paragraph below the Principle of Test Procedure: line:

Principle of Test Procedure:
A large number of Mode S-only All-Call interrogations (UF=11) are made for each of the PR codes. For each PR code, a specified fraction of the interrogations will result in a reply. One hundred interrogations would provide a valid sample for active PR codes while a lesser number would be adequate for other codes.

(**1.87**) In RTCA DO-181D, in section §2.5.4.13.a, in order to address the possible failure of the test identified in the table for a transponder not locked out to All-Calls, and discussed in Working Paper SC209-WP12-07R1, add the following *Note* just after the table:

Note: *This test is based on a small sample, and is likely that in some cases of testing, statistical variation may cause a correctly implemented transponder to fail this test. In this case, it is equally likely that if the test is rerun one or more times, it may then be successful.*

(**1.88**) In RTCA DO-181D, in section §2.5.4.13.b, in order to clarify which specific Timers are being referenced, replace the text of the first paragraph with the following:

The transponder can be in 79 different specific lockout states as determined by the running of the one T_D and the 78 T_L timers. The following test sequence must be repeated for each of the lockout states:

(**1.89**) In RTCA DO-181D, in section §2.5.4.18, as a result of changes to the Comm-B Protocol flowchart identified in Working Paper SC209-WP11-09R1, there were necessary changes to Procedure #18 for the Comm-B Protocol, that were identified in Working Paper SC209-WP12-08R1. Therefore, incorporate all of the identified changes in Working Paper SC209-WP12-08R1.

(**1.90**) In RTCA DO-181D, in section §2.6.2, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, add the following *Note* after sub-bullet "b:"

Note: *Extraction of a Register or a Comm-B broadcast using an SI code is performed in §2.6.6.1.*

(**1.91**) In RTCA DO-181D, in section §2.6.3.2.2, in order to account for the changes that were made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent corresponding changes being proposed in ICAO Doc 9871, Edition 2, the definition of the Mode S Subnetwork Version Number in RTCA DO-181E and EUROCAE ED-73E will have to change accordingly. Replace the reference to Subnetwork Version Number in the text of the paragraph as follows:

Continue to interrogate the transponder as required in §2.6.3.2.1. Verify that the transponder replies with a DF=20 reply with bits 49 - 55 ("Mode S Subnetwork Version Number" subfield [bits 17 - 23 of the "MB" field]) encoded with a value of "~~3~~5" or more.

(**1.92**) In RTCA DO-181D, in several sections in §2.6.6 there are references to ICAO Annex 10, Volume III, Part 1, Amendment 71. With this Change document, these references to specific Amendments will be removed, so as not to require updates in the future. Remove references to ICAO Annex 10 Amendments in the following locations:

§2.6.6.1.a.(1) Note 2 inside the Table
§2.6.6.1.a.(2) Note 1 inside the Table
§2.6.6.5.a.(1) Note 2 inside the Table
§2.6.6.5.a.(2) Note 1 inside the Table
§2.6.6.6.a.(1) Note 2 inside the Table
§2.6.6.6.a.(2) Note 1 inside the Table

(**1.93**) In RTCA DO-181D, in section §2.6.6.1.c, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, add the following at the end of sub-bullet "c" and just prior to the text of sub-bullet "d:"

Repeat the following interrogation in order to extract the Comm-B broadcast message using an SI code (DI=3).

COMM-B BROADCAST EXTRACTION INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14-16	17 - 22	23	24-27	28 --- 32
				"SD"			
"UF" =	**"PC" =**	**"RR" =**	**"DI" =**	**"SIS" =**	**"LSS" =**	**"RRS" =**	**"XX" =**
4	**0**	**16** (10 HEX)	**3**	**1**	**1**	**0**	**0**

Verify that the transponder replies with a "DF" = 20 reply with the "MB" field providing Aircraft Identification data as follows:

Part 1. c. DF = 20, Register 20_{16} - Aircraft Identification "MB" Field									
Reply Bits:	33 --- 40	41 -- 46	47 -- 52	53 -- 58	59 -- 64	65 -- 70	71 --76	77 -- 82	83 -- 88
"MB" Bits:	1 --- 8	9 --- 14	15 -- 20	21 -- 26	27 -- 32	33 -- 38	39 -- 44	45 -- 50	51 -- 56
Field:	**BDS**	**Char. 1**	**Char. 2**	**Char. 3**	**Char. 4**	**Char. 5**	**Char. 6**	**Char. 7**	**Char. 8**
Data:	0010 0000	010101	001010	010101	001010	010101	001010	010101	001010
Character:		**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**	**"U"**	**"J"**

(**1.94**) In RTCA DO-181D, in section §2.6.6.1.g, as discussed in Working Paper SC209-WP13-05, there are minor changes necessary in the ELS and EHS test procedures in order to allow for the maximum time of 60 seconds for a change in BDS 1,7 to be reflected into BDS 1,0. Make the following changes to the paragraph and the *Note* just below the un-numbered table in §2.6.6.1.g:

Within ~~SIX (6)~~ 66 seconds of starting the interrogations, verify that the transponder replies with a DF=20 reply with:

Note: *The ~~SIX (6)~~ 66 seconds is based on the update rate specified for Register 17_{16} plus the update time of up to 60 seconds ~~rate~~ for Register 10_{16} to update Bit 68.*

(**1.95**) In RTCA DO-181D, in section §2.6.6.1.h, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, add the following at the end of sub-bullet "h" and just prior to the text of sub-bullet "i:"

Repeat the extraction of Register 17_{16} using the following GICB extraction interrogation in order to use the format for SI code (DI=3) and verify that the content is the same as the content of Register 17_{16} previously extracted using DI=7.

REGISTER 17_{16} COMMON USAGE GICB CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14-16	17 - 22	23	24-27	28 --- 32
				"SD"			
"UF"	**"PC"**	**"RR"**	**"DI"**	**"SIS"**	**"LSS"**	**"RRS"**	**Not Assigned**
4	**0**	**17** (11 HEX)	**3**	**1**	**1**	**7**	**0**

(**1.96**) In RTCA DO-181D, in section §2.6.6.1.i, in order to adjust the requirements to account for Comm-B extraction using DI=3, as suggested in Working Paper SC209-WP11-09R1, add the following at the end of sub-bullet "i" and just prior to the text of §2.6.6.2:

Repeat the extraction of Register 18_{16} using the following GICB extraction interrogation in order to use the format for SI code (DI=3) and verify that the content is the same as the content of Register 18_{16} previously extracted using DI=7.

REGISTER 18_{16} MODE S SPECIFIC SERVICES CAPABILITY GICB EXTRACTION EXTENDED DATA SOURCE INTERROGATION SETUP USING DI=3							
1 --- 5	6 --- 8	9 --- 13	14-16	17 - 22	23	24-27	28 --- 32
				"SD"			
"UF"	**"PC"**	**"RR"**	**"DI"**	**"SIS"**	**"LSS"**	**"RRS"**	**Not Assigned**
4	**0**	**17** (11 HEX)	**3**	**1**	**1**	**8**	**0**

(**1.97**) In RTCA DO-181D, in section §2.7.1.2.2, in order to account for the changes that were made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent corresponding changes being proposed in ICAO Doc 9871, Edition 2, the definition of the Mode S Subnetwork Version Number in RTCA DO-181E and EUROCAE ED-73E will have to change accordingly. Replace the reference to Subnetwork Version Number in the text of the paragraph as follows:

Continue to interrogate the transponder as required in §2.7.1.2.1. Verify that the transponder replies with a DF=20 reply with bits 49 through 55 ("Mode S Subnetwork Version Number" subfield [bits 17 through 23 of the "MB" field]) encoded with a value of "~~3~~5" or more.

(**1.98**) In RTCA DO-181D, in section §2.7.5.6.d, in order to correct an error in logic during the creation of this test procedure, make the following changes to §2.7.5.6.d.(2):

(2). Bit 55 (bit 23 of the "MB" field) set to "~~1~~0" to indicate that Register $5F_{16}$ servicing capability has been ~~established and that data is valid~~ terminated because of the loss of data.

(**1.99**) In RTCA DO-181D, in section §2.7.5.15.d, in order to correct an error in logic during the creation of this test procedure, make the following changes to §2.7.5.15.d.(2):

(2). Bit 55 (bit 23 of the "MB" field) set to "~~1~~0" to indicate that Register $5F_{16}$ servicing capability has been ~~established and that data is valid~~ terminated because of the loss of data.

(**1.100**) In RTCA DO-181D, in numerous sections, starting with §2.7.6.2.f, as discussed in Working Paper SC209-WP13-05, there are minor changes necessary in the ELS and EHS test procedures in order to allow for the maximum time of 60 seconds for a change in BDS 1,7 to be reflected into BDS 1,0. In each of the sections identified in the matrix below, change the value of "TEN (10) seconds" in the sentence below the table to a value of "67" seconds:

§2.7.6.2.f	§2.7.6.12.f	§2.7.7.8.f
§2.7.6.3.f	§2.7.6.14.f	§2.7.7.10.f
§2.7.6.4.f	§2.7.7.2.f	§2.7.7.12.f
§2.7.6.6.f	§2.7.7.3.f	§2.7.7.14.f
§2.7.6.8.f	§2.7.7.4.f	
§2.7.6.10.f	§2.7.7.6.f	

(**1.101**) In RTCA DO-181D, in section §2.7.6.15, add the following *Note* to clarify the use of GPS data sources:

Note: *GPS Data Sources may not provide data more often than once every 1.2 seconds. If GPS Data Sources are used to provide data, ensure that the data is provided at the minimum rate of once every 1.2 seconds. For Register 50_{16}, this may apply to the True Track Angle data and/or Ground Speed data.*

(**1.102**) In RTCA DO-181D, in section §2.7.7.14, make the following changes in subsection "a:"

a. **Data / Source Change - Set 1:** (§2.2.25.8.2)

(1). Magnetic Heading Data Input: (§2.2.25.8.2.1)
Via an appropriate input interface, set the rate at which valid Magnetic Heading data is provided to less than once ~~per two~~ in 2.6 seconds.

(2). Indicated Airspeed Data Input - ADS: (§2.2.25.8.2.2)
Via an appropriate input interface, set the rate at which valid Indicated Airspeed data is provided to less than once ~~per two~~ in 2.6 seconds.

(3). Mach Data Input - ADS: (§2.2.25.8.2.3)
Via an appropriate input interface, set the rate at which valid Mach data is provided to less than once ~~per two~~ in 2.6 seconds.

(4). Barometric Altitude Rate Data Input - ADS: (§2.2.25.8.2.4)
Via an appropriate input interface, set the rate at which valid Barometric Altitude Rate data is provided to less than once ~~per two~~ in 2.6 seconds.

(5). Inertial Vertical Rate Data Input - FMS / IRS: (§2.2.25.8.2.5)
Via an appropriate input interface, set the rate at which valid Inertial Vertical Rate data is provided to less than once ~~per two~~ in 2.6 seconds.

(**1.103**) In RTCA DO-181D, in section §2.7.7.15, add the following *Note* to clarify the use of GPS data sources:

Note: *GPS Data Sources may not provide data more often than once every 1.2 seconds. If GPS Data Sources are used to provide data, ensure that the data is provided at the minimum rate of once every 1.2 seconds. For Register 60_{16}, this may apply to the Inertial Vertical Rate data.*

(**1.104**) In RTCA DO-181D, in section §2.8.4, in bullets "a" and "b," in order to correct a problem with Table references in Appendix B, make the following changes identified below in yellow:

a. Verify that the servicing of Register $\mathbf{XX_{16}}$ during the power-on cycle of the transponder is properly reported in Registers 18_{16} through $1C_{16}$ as required in Appendix B, Table B-3-24 to Table B-3-28.

b. Verify that the real-time (not just since power-on) servicing of Register $\mathbf{XX_{16}}$ is properly reported in Register 17_{16} (see Appendix B, Table B-3-23) if such reporting is required for Register $\mathbf{XX_{16}}$.

(**1.105**) In RTCA DO-181D, in section §3.3.3, there is a discrepancy with the same paragraph §6.4.4.1 in ED-73C. In order to harmonize DO-181E with ED-73E, make the following changes:

Interrogate the installed transponder and verify that the reply frequency of the system is 1090 ±~~3~~ 1 MHz ~~for aircraft operating below 15,000 feet, or 1090, ±1 MHz for aircraft operating above 15,000 feet~~.

(**1.106**) In RTCA DO-181D, in Appendix A, section §A.1, add the following acronyms:

QFE – Aviation “Q” Code for “Field Elevation”
QNE – Aviation “Q” Code for “Nautical Height” for Enroute
QNH – Aviation “Q” Code for “Nautical Height”

(**1.107**) In RTCA DO-181D, in Appendix A, section §A.2, edit and add the following definitions:

Event-Driven – Messages that are broadcast periodically for a duration of the operational condition. Examples of Event-Driven Messages include the Extended Squitter Aircraft Status Message with the Emergency/Priority Status and TCAS RA Broadcast subtypes, ~~Operational Status and Target State and Status Messages~~ (ref. RTCA/DO-260~~A~~ B/EUROCAE ED-102A).

Periodic Status – Status Messages that are broadcast independently in the same manner as the Airborne Position, Surface Position, Airborne Velocity and Aircraft Identification Messages. Examples of Periodic Status Messages include the Target State and Status and the Aircraft Operational Status (ref. RTCA DO-260B / EUROCAE ED-102A).

QFE – Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above the station, whether airborne or on the ground.

QNE – The barometric pressure used for the standard altimeter setting (29.92 inches Hg, 1013.25 hectopascals).

QNH – Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above mean sea level, whether airborne or on the ground.

(**1.108**) In RTCA DO-181D, in Appendix B, there are several references to ICAO Doc 9871, Edition 1. There are specific paragraph references to guidance materials in Doc 9871, Edition 1, Appendix C, which will change to Appendix D in Doc 9871, Edition 2. In the titles of the following subparagraphs in Appendix B, make the specified changes to the paragraph reference which will exist in ICAO Doc 9871, Edition 2:

In the title of §B.4.1 **change** §C.2.4.1 **to** Edition 2, §D.2.4.1
In the title of §B.4.2 **change** §C.2.4.2 **to** Edition 2, §D.2.4.2
In the title of §B.4.3 **change** §C.2.4.3 **to** Edition 2, §D.2.4.3
In the title of §B.4.4 **change** §C.2.4.4 **to** Edition 2, §D.2.4.4
In the title of §B.4.5 **change** §C.2.4.5 **to** Edition 2, §D.2.4.5
In the title of §B.4.6 **change** §C.2.4.6 **to** Edition 2, §D.2.4.6

(**1.109**) In RTCA DO-181D, in Appendix B, section §B.2.1 inside Table B-2-1, revise the entry for Register 62_{16} by removing reference to "Reserved for" and setting the Maximum Update Interval to 0.5 seconds:

Transponder Register No.	*Assignment*	*Maximum update interval (see Note 1)*
62_{16}	~~Reserved for~~ Target State and Status Information	~~N/A~~ 0.5s

(**1.110**) In RTCA DO-181D, in Appendix B, section §B.2.1, in order to resolve the coordination of documents with regard to the issue of timeout issues related to Registers 08_{16} and 20_{16} initially raised by Kevin Wilson of Honeywell and discussed in Working Papers SC209-WP10-04 and SC209-WP11-04 by Bob Saffell of Rockwell Collins, add the following *Note #2* after the existing *Note* at the bottom of Table B-2-1:

***Note 2**: If Extended Squitter is implemented, then Register 08_{16} is not cleared or ZEROed once either Flight Identification or Aircraft Registration data has been loaded into the Register during the current power-on cycle. Register 08_{16} is not cleared since it provides information that is fundamental to track file management in the ADS-B environment. (See §2.2.5.1.11.c of RTCA DO-260B / EUROCAE ED-102A). Refer to §B.4.3.3 for implementation guidelines regarding Register 08_{16} and 20_{16}.*

(**1.111**) In RTCA DO-181D, in Appendix B, section §B.3 just prior to Table B-3-7 there is an un-numbered table containing references to "ADS-B Registers." Because of the changes in RTCA DO-260B and EUROCAE ED-102A defining the ADS-B Periodic Status Messages and removing them from being broadcast by the Event-Driven protocol, edit the text, the un-numbered table and the *Note* just prior to Table B-3-7 as follows:

For additional information on the following ADS-B Registers, please reference RTCA/DO-260~~A~~ B / EUROCAE ED-102A:

Table B-3-5	BDS Code 0,5	Extended Squitter Airborne Position
Table B-3-6	BDS Code 0,6	Extended Squitter Surface Position
Table B-3-7	BDS Code 0,7	Extended Squitter Status (see *Note*)
Table B-3-8	BDS Code 0,8	Extended Squitter Aircraft Identification and Category
Table B-3-9a	BDS Code 0,9	Extended Squitter Airborne Velocity (Subtypes 1 and 2 – Velocity Over Ground)
Table B-3-9b	BDS Code 0,9	Extended Squitter Airborne Velocity (Subtypes 3 and 4 – Airspeed and Heading)
Table B-3-10	BDS Code 0,A	Extended Squitter Event-Driven Information
Table B-3-97-1	BDS Code 6,1	Extended Squitter Aircraft Status (Subtype =1 – Emergency/Priority Status)
Table B-3-97-2	BDS Code 6,1	Extended Squitter Aircraft Status (Subtype=2 – TCAS RA Broadcast)
Table B-3-98	BDS Code 6,2	Target State and Status
Table B-3-101	BDS Code 6,5	Extended Squitter Aircraft Operational Status

Note: *The 1090 Extended Squitter Status Register~~s~~ ~~are~~ is ~~actually~~ provided in this section since ~~they are~~ it is not squittered and is intended to be accessed through GICB protocols.*

(**1.112**) In RTCA DO-181D, in Appendix B, section §B.3, Table B-3-16 describes the format for Register 10_{16}. In order to account for the changes that were made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent corresponding changes being proposed in ICAO Doc 9871, Edition 2, the following additional reference should be added in Note #1 of Table B-3-16:

1) Annex 10 Volume IV, §3.1.2.6.10.2 and §4.3.8.4.2.2.2.

(**1.113**) In RTCA DO-181D, in Appendix B, section §B.3, Table B-3-16 describes the format for Register 10_{16}. In order to account for the changes that were made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent corresponding changes being proposed in ICAO Doc 9871, Edition 2, the definition of the Mode S Subnetwork Version Number in RTCA DO-181E and EUROCAE ED-73E will have to change accordingly. Replace the description of the Mode S Subnetwork Version Number field, Bits 17 through 23, in *Note* #12 of Table B-3-16 with the following:

Version Number	ICAO	RTCA	EUROCAE
0	Mode S Subnetwork Not Available		
1	ICAO Doc 9688 (1996)		
2	ICAO Doc 9688 (1998)		
3	ICAO Annex 10, Vol III, Amendment 77		
4	ICAO Doc 9871, Edition 1	DO-181D	ED-73C
5	ICAO Doc 9871, Edition 2	DO-181E	ED-73E
6–127	~~Unassigned~~ Reserved		

(**1.114**) In RTCA DO-181D, in Appendix B, section §B.3, Table B-3-23, in order to harmonize the naming of the Extended Squitter Identification and Category Message across all documents, in the definition table for Register 17_{16}, make the following changes for bit #4:

0,8 Extended Squitter ~~Type and~~ Identification and Category

(**1.115**) In RTCA DO-181D, in Appendix B, section §B.3, Table B-3-48, Note 1 has an incorrect reference:

In Note 1 of Table B-3-48 **replace** §2.2.22.1.2.1.3 **with** §2.2.22.1.2.1

(**1.116**) In RTCA DO-181D, in Appendix B, section §B.3, Table B-3-64, as agreed in Working Paper SC209-WP12-04, indicate that the Reserved Bits in Register 40_{16} shall be set to ZERO (0). Make the following changes in the Register 40_{16} definition:

1	STATUS	
2	MSB = 32768 feet	
3		
4		
5	MCP/FCU SELECTED ALTITUDE	
6		
7	Range = [0, 65520] feet	
8		
9		
10		
11		
12		
13	LSB = 16 feet	
14	STATUS	
15	MSB = 32768 feet	
16		
17		
18	FMS SELECTED ALTITUDE	
19		
20	Range = [0, 65520] feet	
21		
22		
23		
24		
25		
26	LSB = 16 feet	
27	STATUS	
28	MSB = 204.8 mb	
29		
30		
31		
32	BAROMETRIC PRESSURE SETTING	
33	MINUS 800 mb	
34		
35	Range = [0, 410] mb	
36		
37		
38		
39	LSB = 0.1 mb	
40		
41		
42		
43		
44	RESERVED	
45		
46		
47		
48	STATUS OF MCP/FCU MODE BITS	
49	VNAV MODE	
50	ALT HOLD MODE	MCP/FCU Mode bits
51	APPROACH MODE	
52	RESERVED	
53		
54	STATUS OF TARGET ALT SOURCE BITS	
55	MSB TARGET ALT SOURCE	
56	LSB	

PURPOSE: To provide ready access to information about the aircraft's current vertical intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

1) Target altitude shall be the short-term intent value, at which the aircraft will level off (or has leveled off) at the end of the current maneuver. The data source that the aircraft is currently using to determine the target altitude shall be indicated in the altitude source bits (54 to 56) as detailed below.

Note: *This information which represents the real "aircraft intent," when available, represented by the altitude control panel selected altitude, the flight management system selected altitude, or the current aircraft altitude according to the aircraft's mode of flight (the intent may not be available at all when the pilot is flying the aircraft).*

2) The data entered into bits 1 to 13 shall be derived from the mode control panel/flight control unit or equivalent equipment. Alerting devices may be used to provide data if it is not available from "control" equipment. The associated mode bits for this field (48 to 51) shall be as detailed below.

3) The data entered into bits 14 to 26 shall de derived from the flight management system or equivalent equipment managing the vertical profile of the aircraft.

4) The current barometric pressure setting shall be calculated from the value contained in the field (bits 28 to 39) plus 800 mb. When the barometric pressure setting is less than 800 mb or greater than 1209.5 mb, the status bit for this field (bit 27) shall be set to indicate invalid data.

5) Reserved bits 40 to 47 shall be set to ZERO (0).

6) Bits 48 to 56 shall indicate the status of the values provided in bits 1 to 26 as follows:

Bit 48 shall indicate whether the mode bits (49, 50 and 51) are already being populated:
- 0 = No mode information provided
- 1 = Mode information deliberately provided

Bits 49, 50 and 51:
- 0 = Not active
- 1 = Active

Reserved bits 52 and 53 shall be set to ZERO (0).

Bit 54 shall indicate whether the target altitude source bits (55 and 56) are actively being populated:
- 0 = No source information provided
- 1 = Source information deliberately provided

Bits 55 and 56 shall indicate target altitude source:
- 00 = Unknown
- 01 = Aircraft altitude
- 10 = FCU/MCP selected altitude
- 11 = FMS selected altitude

Note: *Additional implementation guidelines are provided in §B.4.4 of this Appendix.*

(**1.117**) In RTCA DO-181D, in Appendix B, section §B.3, delete Table B-3-97-1 as it is defined in RTCA DO-260B / EUROCAE ED-102A as Register 61_{16}, Subtype=1, containing the ADS-B Version=2 Extended Squitter Status Message for the broadcast of the Emergency/Priority Status and Mode A Code, and referenced in an un-numbered table in section §B.3 just prior to Table B-3-7.

(**1.118**) In RTCA DO-181D, in Appendix B, section §B.3, delete Table B-3-97-2 as it is defined in RTCA DO-260B / EUROCAE ED-102A as Register 61_{16}, Subtype=2, containing the ADS-B Version =2 Extended Squitter Status Message for the TCAS RA broadcast, and referenced in an un-numbered table in section §B.3 just prior to Table B-3-7.

(**1.119**) In RTCA DO-181D, in Appendix B, section §B.3, delete Table B-3-98 as it is defined in RTCA DO-260B / EUROCAE ED-102A as Register 62_{16}, Subtype=1, containing the ADS-B Version=2 Extended Squitter Target State and Status Message, and referenced in an un-numbered table in section §B.3 just prior to Table B-3-7.

(**1.120**) In RTCA DO-181D, in Appendix B, section §B.3, delete Table B-3-101 as it is defined in RTCA DO-260B / EUROCAE ED-102A as Register 65_{16}, containing the ADS-B Version=2 Extended Squitter Aircraft Operational Status Message, and referenced in an un-numbered table in section §B.3 just prior to Table B-3-7.

(**1.121**) In RTCA DO-181D, in Appendix B, section §B.4.1.3 describes the Mode S Subnetwork Version Number. In order to account for the changes that were made in the ADS-B MOPS (RTCA DO-260B / EUROCAE ED-102A) and subsequent corresponding changes being proposed in ICAO Doc 9871, Edition 2, the definition of the Mode S Subnetwork Version Number in RTCA DO-181E and EUROCAE ED-73E will have to change accordingly. At the beginning of §B.4.1.3, replace the definition of Bits 17 – 23 for the Mode S Subnetwork Version Number with the following:

Bits 17 – 23 reflect the Mode S Subnetwork Version Number.

Version Number	**ICAO**	**RTCA**	**EUROCAE**
0	Mode S Subnetwork Not Available		
1	ICAO Doc 9688 (1996)		
2	ICAO Doc 9688 (1998)		
3	ICAO Annex 10, Vol III, Amendment 77		
4	ICAO Doc 9871, Edition 1	DO-181D	ED-73C
5	ICAO Doc 9871, Edition 2	DO-181E	ED-73E
6–127	~~Unassigned~~ Reserved		

(**1.122**) In RTCA DO-181D, in Appendix B, after section §B.4.3.2 and just prior to section §B.4.4, add a new section to explain implementation considerations for Registers 08_{16} and 20_{16}.

B.4.3.3 Register 20_{16} and 08_{16} Implementation Considerations

Detailed implementation requirements for Register 20_{16} are provided in §2.2.24.6. §B.2.1, Table B-2-1, Note 2 provides an introduction to Register 08_{16} implementation. Implementation of Register 08_{16} should also consider the following:

a. If valid Flight Identification data is available, then the data should be used to populate the character subfields in Register 08_{16}.

b. After using Flight Identification data to populate the character subfields in Register 08_{16} in a given power-on cycle, if Flight Identification data becomes invalid or not available, then the last known valid Flight Identification data should be retained and used to continue population of the character subfields in Register 08_{16} for the duration of the power-on cycle.

c. If valid Flight Identification data is not available, but valid Aircraft Registration data is available in a given power-on cycle, then the valid Aircraft Registration data should be used to populate the character subfields in Register 08_{16} for the duration of the power-on cycle.

d. If Register 08_{16} has been populated using Aircraft Registration data in a given power-on cycle, and valid Flight Identification data becomes available, then the Flight Identification data should be used to populate the character subfields in Register 08_{16} for the remainder of the power-on cycle.

e. Once valid Flight Identification data has been used to populate Register 08_{16} in a given power-on cycle, Aircraft Registration data should not be used to populate the character subfields of Register 08_{16}, even if Flight Identification data becomes invalid or not available during the power-on cycle.

(**1.123**) In RTCA DO-181D, in Appendix B, at the end of section §B.4.4.3, as agreed in Working Paper SC209-WP12-04, add a new guidance material section §B.4.4.4 to indicate that Reserved bits in Register 40_{16} should be set to ZERO (0).

B.4.4.4 Setting of the Reserved Bits (Bits 40 to 47, 52 & 53)

Bits 40 to 47, 52 and 53 of Register 40_{16} “MB” field should be set to ZERO (0).