APPENDIX C

AMENDMENTS TO SARPS FOR SECONDARY SURVEILLANCE RADAR (SSR)

PROPOSED AMENDMENT TO

**INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES**

AERONAUTICAL TELECOMMUNICATIONS

**ANNEX 10
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION**

**VOLUME IV
(SURVEILLANCE RADAR AND COLLISION AVOIDANCE SYSTEMS)**

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT TO ANNEX 10

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:

~~Text to be deleted is shown with a line through it.~~	text to be deleted
New text to be inserted is highlighted with grey shading.	new text to be inserted
~~Text to be deleted is shown with a line through it~~ followed by the replacement text which is highlighted with grey shading.	new text to replace existing text

2. The source of the proposed amendment is the report of the seventh meeting of the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP).

CHAPTER 1. DEFINITIONS

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Note 2.— The Mode S extended squitter system is subject to patent rights from the Massachusetts Institute of Technology (MIT) Lincoln Laboratory. On 22 August 1996, MIT Lincoln Laboratory issued a notice in the Commerce Business Daily *(CBD), a United States Government publication, of its intent not to assert its rights as patent owner against any and all persons in the commercial or non-commercial practice of the patent, in order to promote the widest possible use of the Mode S extended squitter technology. Further, by letter to ICAO dated 27 August 1998, MIT Lincoln Laboratory confirmed that the CBD notice has been provided to satisfy ICAO requirements for a statement of patent rights for techniques that are included in SARPs, and that the patent holders offer this technique free of charge for any use.*

Airborne collision avoidance system (ACAS). 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.

~~*Note 1.— In this context the term “independently” means that ACAS operates independently of other systems used by air traffic services except for communication with Mode S ground stations as defined in Chapter 4, 4.3.6.2.*~~

Note ~~2~~.— SSR transponders referred to above are those operating in Mode C or Mode S.

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CHAPTER 2. GENERAL

2.1 SECONDARY SURVEILLANCE RADAR (SSR)

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2.1.3 Transponder reply modes (air-to-ground)

2.1.3.1 Transponders shall respond to Mode A interrogations in accordance with the provisions of 3.1.1.7.12.1 and to Mode C interrogations in accordance with the provisions of 3.1.1.7.12.2.

Note.— If pressure-altitude information is not available, transponders reply to Mode C interrogations with framing pulses only.

2.1.3.1.1 The pressure altitude reports contained in Mode S replies shall be derived as specified in 3.1.1.7.12.2.2.

Note.— 3.1.1.7.12.2.2 is intended to relate to Mode C replies and specifies, inter alia*, that Mode C pressure altitude reports be referenced to a standard pressure setting of 1013.25 hectopascals. The intention of 2.1.3.1.1 is to ensure that all transponders, not just Mode C transponders, report uncorrected pressure altitude.*

2.1.3.2 Where the need for Mode C automatic pressure-altitude transmission capability within a specified airspace has been determined, transponders, when used within the airspace concerned, shall respond to Mode C interrogations with pressure-altitude encoding in the information pulses.

2.1.3.2.1 From 1 January 1999, all transponders, regardless of the airspace in which they will be used, shall respond to Mode C interrogations with pressure-altitude information.

~~2.1.3.2.2 **Recommendation.—** *All transponders, regardless of the airspace in which they will be used, should respond to Mode C interrogations with pressure-altitude information.*~~

Note.— Operation of the airborne collision avoidance system (ACAS) depends upon intruder aircraft reporting pressure-altitude in Mode C replies.

2.1.3.2.~~3~~2 **Recommendation.—** *For aircraft with 7.62 m (25 ft) or better pressure altitude sources t~~T~~he pressure-altitude information provided by Mode S transponders in response to selective interrogations (i.e. in the AC ~~field) should be reported with the best altitude quantization increment available in the aircraft in accordance with the provisions of 3.1.2.6.5.4~~ field, 3.1.2.6.5.4) should be reported in 7.62 m (25 ft) increments.*

Note.— Performance of the airborne collision avoidance system (ACAS) is significantly enhanced when an intruder aircraft is reporting pressure-altitude in 7.62 m (25 ft) increments.

2.1.3.2.~~4~~3 All Mode A/C transponders installed on or after 1 January 1992 shall report pressure-altitude encoded in the information pulses in Mode C replies.

2.1.3.2.~~5~~4 All Mode S transponders installed on or after 1 January 1992 shall report pressure-altitude encoded in the information pulses in Mode C replies and in the AC field of Mode S replies.

2.1.3.2.5 All Mode S transponder equipped aircraft with 7.62 m (25 ft) or better pressure altitude sources shall report pressure altitude encoded in 7.62 m (25 ft) increments in the AC field of Mode S replies from 1 January 2005.

2.1.3.2.6 When a Mode S transponder reports altitude in 7.62 m (25 ft) increments, the reported value of the altitude shall be the value obtained by expressing the measured value of the uncorrected pressure altitude of the aircraft in 7.62 m (25 ft) increments.

Note.— This requirement relates to the installation and use of the Mode S transponder. The purpose is to ensure that altitude data obtained from a 30.48 m (100 ft) increment source are not reported using the formats intended for 7.62 m (25 ft) data.

2.1.3.3 Transponders used within airspace where the need for Mode S airborne capability has been determined shall also respond to intermode and Mode S interrogations in accordance with the applicable provisions of 3.1.2.

2.1.3.3.1 Requirements for mandatory carriage of SSR Mode S transponders shall be on the basis of regional air navigation agreements which shall specify the airspace and the airborne implementation time-scales.

2.1.3.3.2 **Recommendation.**— *The agreements indicated in 2.1.3.3.1 ~~shall~~ should provide at least ~~seven~~ five years' notice.*

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2.1.5 Mode S airborne equipment capability

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2.1.5.1.7 *SI capability* — Transponders with the ability to process SI codes shall have the capabilities of 2.1.5.1.2, 2.1.5.1.3, 2.1.5.1.4 or 2.1.5.1.5 and also those prescribed for SI code operation (3.1.2.3.2.1.4, 3.1.2.5.2.1, 3.1.2.6.1.3, 3.1.2.6.1.4.1~~.~~, 3.1.2.6.9.1.1 and 3.1.2.6.9.2). Transponders with this capability shall be designated with a suffix "s".

Note.— For example, a level 4 transponder with extended squitter capability and SI capability would be designated "level 4es".

2.1.5.1.7.1 SI code capability shall be provided in accordance with the provisions of 2.1.5.1.7 for all Mode S transponders installed on or after 1 January 2003 and by all Mode S transponders by 1 January 2005.

Note.— Mandates from certain States may require applicability in advance of these dates.

2.1.5.1.8 *Extended squitter non-transponder devices.* Devices that are capable of broadcasting extended squitters that are not part of a Mode S transponder shall conform to all of the 1 090 MHz RF signals in space requirements specified for a Mode S transponder.

2.1.5.2 All Mode S transponders used by international civil air traffic shall conform, at least, to the requirements of Level 2 prescribed in 2.1.5.1.2.

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2.1.5.3 Mode S transponders installed on aircraft with gross mass in excess of 5 700 kg or a maximum cruising true airspeed capability in excess of ~~324~~ 463 km/h (~~175~~ 250 kt) shall operate with antenna diversity as prescribed in 3.1.2.10.4 if:

a) the aircraft individual certificate of airworthiness is first issued on or after 1 January 1990; or

b) Mode S transponder carriage is required on the basis of regional air navigation agreement in accordance with 2.1.3.3.1 and 2.1.3.3.2.

Note.— Aircraft with maximum cruising true airspeed exceeding 324 km/h (175 kt) are required to operate with a peak power of not less than 21.0 dBW as specified in 3.1.2.10.2 c).

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CHAPTER 3. SURVEILLANCE RADAR SYSTEMS

3.1 SECONDARY SURVEILLANCE RADAR (SSR) SYSTEM CHARACTERISTICS

Note 1.— Section 3.1.1 prescribes the technical characteristics of SSR systems having only Mode A and Mode C capabilities. Section 3.1.2 prescribes the characteristics of systems with Mode S capabilities.

~~*Note 2.— Non-SI alternative units are used as permitted by Annex 5, Chapter 3, paragraph 3.2.2.*~~

Note 2.— 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 ACAS.

*Note 3.— Non-**Standard-International** alternative units are used as permitted by Annex 5, Chapter 3, paragraph 3.2.2.*

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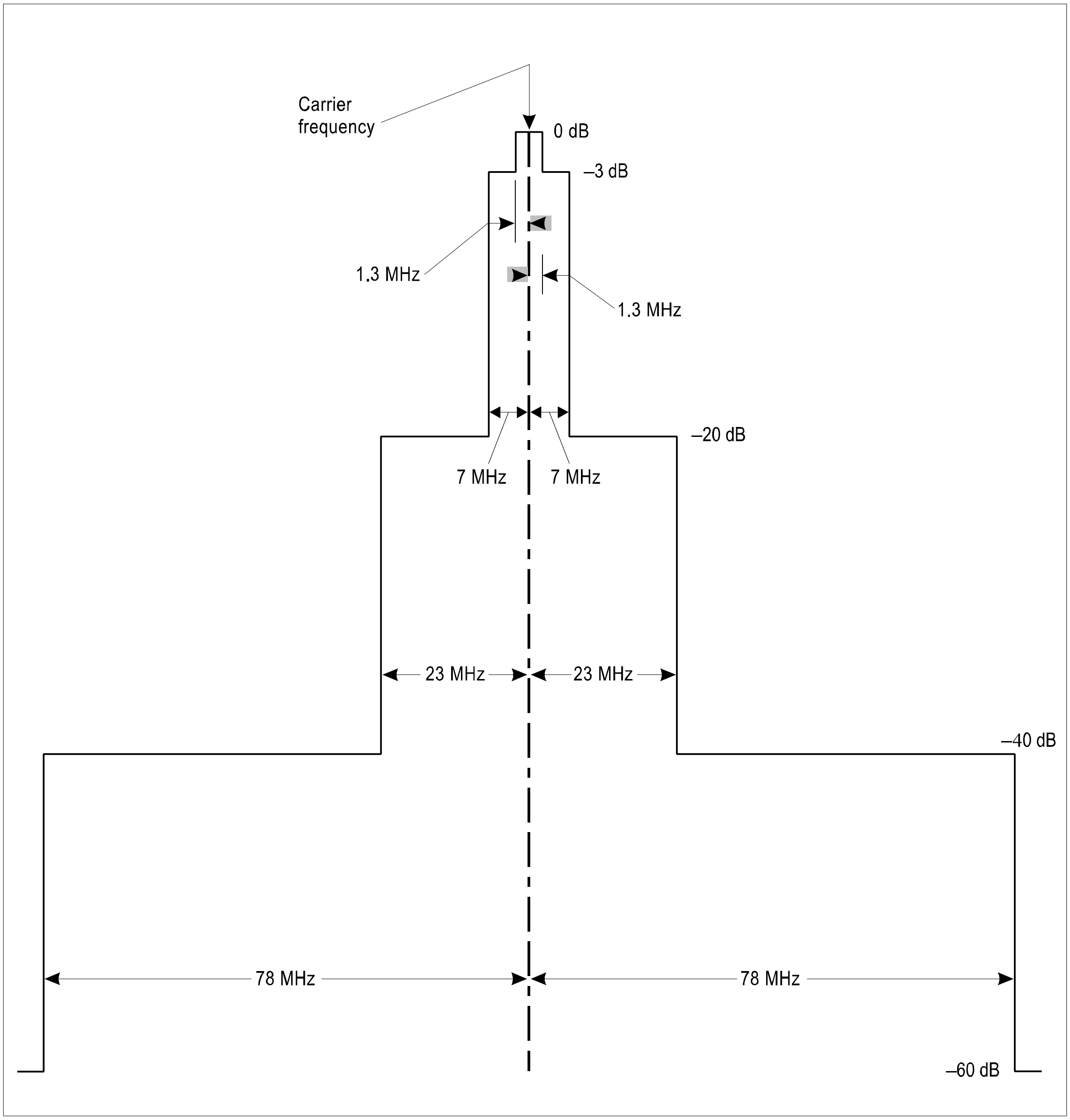

Figure 3-5 Required spectrum limits for transponder transmitter

Note.— This figure shows the spectrum centred on the carrier frequency and will therefore shift in its entirety plus or minus 1 MHz along with the carrier frequency.

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Format No.	DF				
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~~18~~	~~10010~~	~~27 or 83~~			~~P:24~~
18	10010	CF:3	AA:24	ME:56	PI:24 ... Extended squitter/non transponder
~~19~~	~~10011~~	~~27 or 83~~			
19	10011	AF:3	104		... Military extended squitter

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Figure 3-8. Summary of Mode S reply or downlink formats

Table 3-3. Field definitions

Field		*Format*		
Designator	*Function*	*UF*	*DF*	*Reference*
AA	Address announced		11, 17, 18	3.1.2.5.2.2.2
AC	Altitude code		4, 20	3.1.2.6.5.4
AF	Application field		19	3.1.2.8.8.2
AP	Address/parity	All	0, 4, 5, 16, 20, 21, 24	3.1.2.3.2.1.3
AQ	Acquisition	0		3.1.2.8.1.1
CA	Capability		11, 17	3.1.2.5.2.2.1
CC	Cross-link capability		0	3.1.2.8.2.3
CF	Control field		18	3.1.2.8.7.2
CL	Code label	11		3.1.2.5.2.1.3
DF	Downlink format		All	3.1.2.3.2.1.2
DI	Designator identification	4, 5, 20, 21		3.1.2.6.1.3
DR	Downlink request		4, 5, 20, 21	3.1.2.6.5.2
DS	Data selector	0		3.1.2.8.1.3
FS	Flight status		4, 5, 20, 21	3.1.2.6.5.1

Field		*Format*		
Designator	*Function*	*UF*	*DF*	*Reference*
IC	Interrogator code	11		3.1.2.5.2.1.2
ID	Identity		5, 21	3.1.2.6.7.1
KE	Control, ELM		24	3.1.2.7.3.1
MA	Message, Comm-A	20, 21		3.1.2.6.2.1
MB	Message, Comm-B		20, 21	3.1.2.6.6.1
MC	Message, Comm-C	24		3.1.2.7.1.3
MD	Message, Comm-D		24	3.1.2.7.3.3
ME	Message, extended squitter		17, 18	3.1.2.8.6.2
MU	Message, ACAS	16		4.3.8.4.2.3
MV	Message, ACAS		16	3.1.2.8.3.1, 4.3.8.4.2.4
NC	Number of C-segment	24		3.1.2.7.1.2
ND	Number of D-segment		24	3.1.2.7.3.2
PC	Protocol	4, 5, 20, 21		3.1.2.6.1.1
PI	Parity/interrogator identifier		11, 17, 18	3.1.2.3.2.1.4
PR	Probability of reply	11		3.1.2.5.2.1.1
RC	Reply control	24		3.1.2.7.1.1
RI	Reply information		0	3.1.2.8.2.2
RL	Reply length	0		3.1.2.8.1.2
RR	Reply request	4, 5, 20, 21		3.1.2.6.1.2
SD	Special designator	4, 5, 20, 21		3.1.2.6.1.4
UF	Uplink format	All		3.1.2.3.2.1.1
UM	Utility message		4, 5, 20, 21	3.1.2.6.5.3
VS	Vertical status		0	3.1.2.8.2.1

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3.1.2.3.2.1.4 *PI: Parity/interrogator identifier*. This 24-bit (33-56) or (89-112) downlink field shall have parity overlaid on the interrogator's identity code according to 3.1.2.3.3.2 and shall appear in the Mode S all-call reply, DF = 11 and in the extended squitter, DF = 17 or DF = 18. If the reply is made in response to a Mode A/C/S all-call, a Mode S-only all-call with CL field (3.1.2.5.2.1.3) and IC field (3.1.2.5.2.1.2) equal to 0, or is an acquisition or an extended squitter (3.1.2.8.5, 3.1.2.8.6 or 3.1.2.8.7), the II and the SI codes shall be 0.

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3.1.2.5.2.1.2 *IC: Interrogator code*. This 4-bit (10-13) uplink field shall contain either the 4-bit interrogator identifier code (3.1.2.5.2.1.2.~~1~~3) or the lower 4 bits of the 6-bit surveillance identifier code (3.1.2.5.2.1.2.~~2~~4) depending on the value of the CL field (3.1.2.5.2.1.~~3~~3).

3.1.2.5.2.1.2.1 **Recommendation.—** *It is recommended that whenever possible an interrogator should operate using a single interrogator code.*

3.1.2.5.2.1.2.2 *The use of multiple interrogator codes by one interrogator*. An interrogator may use more than one interrogator code and may use different interrogator codes in different interrogations. An interrogator shall only use multiple interrogator codes on a sector basis and shall not use more than two interrogator codes.

~~3.1.2.5.2.1.2.1~~ 3.1.2.5.2.1.2.3 *II: Interrogator identifier*. This 4-bit value shall define an interrogator identifier (II) code. These II codes shall be assigned to interrogators in the range from 0 to 15. The II code value of 0 shall only be used for supplementary acquisition in conjunction with acquisition based on lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5). When two II codes are assigned to one interrogator only, one II code shall be used for full data link purposes. Limited data link activity including single segment Comm-A, uplink and downlink broadcast protocols and GICB extraction may be performed by both II codes.

~~*Note.— An interrogator may be assigned more than one identifier code and may use different codes in different interrogations.*~~

~~3.1.2.5.2.1.2.2~~ 3.1.2.5.2.1.2.4 *SI: Surveillance identifier*. This 6-bit value shall define a surveillance identifier (SI) code. These SI codes shall be assigned to interrogators in the range from 1 to 63. The SI code value of 0 shall not be used. The SI codes shall be used with the multisite lockout protocols (3.1.2.6.9.1). The SI codes shall not be used with the multisite communications protocols (3.1.2.6.11.3.2, 3.1.2.7.4 or 3.1.2.7.7).

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3.1.2.5.2.2.1 *CA: Capability.* This 3-bit (6-8) downlink field shall contain an encoded definition of the communications capability of the transponder and shall be used in the all-call reply format (DF = 11).

Coding

0 signifies no communications capability (surveillance only), and no ability to set CA code 7 and either airborne or on the ground
1 reserved
2 reserved
3 reserved
4 signifies at least Comm-A and Comm-B capability and ability to set CA code 7 and on the ground
5 signifies at least Comm-A and Comm-B capability and ability to set CA code 7 and airborne
6 signifies at least Comm-A and Comm-B capability and ability to set CA code 7 and either airborne or on the ground
7 signifies the DR field is not equal to 0 or the FS field equals 2, 3, 4 or 5, and either airborne or on the ground

When the conditions for CA code 7 are not satisfied, installations that have communications capability but do not have automatic means to set the on-the-ground condition shall use CA code 6. Aircraft with automatic on-the-ground determination shall use CA code 4 or 5. Data link capability reports (3.1.2.6.10.2.2) shall be available from aircraft installations that set CA code 4, 5, 6 or 7.

Note.— CA codes 1 to 3 are reserved for use by Mode S transponders that do not have the ability to set CA code 7. Transponders with these codes will provide a data link capability report (3.1.2.6.10.2.2). No data link transactions other than GICB extraction including aircraft identity, ACAS RA extraction, and downlink broadcast extraction, should be attempted with these transponders.

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3.1.2.6.1.4.1 *Subfields in SD.* The SD field shall contain information as follows:

a) If DI = 0, 1 or 7:

IIS, the 4-bit (17-20) interrogator identifier subfield shall contain an assigned identifier code of the interrogator (~~3.1.2.5.2.1.2~~ 3.1.2.5.2.1.2.3).

b) If DI = 0:

bits 21-32 are not assigned.

c) If DI = 1:

MBS, the 2-bit (21, 22) multisite Comm-B subfield shall have the following codes:

0 signifies no Comm-B action
1 signifies air-initiated Comm-B reservation request (3.1.2.6.11.3.1)
2 signifies Comm-B closeout (3.1.2.6.11.3.2.3)
3 not assigned.

MES, the 3-bit (23-25) multisite ELM subfield shall contain reservation and closeout commands for ELM as follows:

0 signifies no ELM action
1 signifies uplink ELM reservation request (3.1.2.7.4.1)
2 signifies uplink ELM closeout (3.1.2.7.4.2.8)
3 signifies downlink ELM reservation request (3.1.2.7.7.1.1)
4 signifies downlink ELM closeout (3.1.2.7.7.3)
5 signifies uplink ELM reservation request and downlink ELM closeout
6 signifies uplink ELM closeout and downlink ELM reservation request
7 signifies uplink ELM and downlink ELM closeouts.

RSS, the 2-bit (27, 28) reservation status subfield shall request the transponder to report its reservation status in the UM field. The following codes have been assigned:

0 signifies no request
1 signifies report Comm-B reservation status in UM
2 signifies report uplink ELM reservation status in UM
3 signifies report downlink ELM reservation status in UM.

d) If DI = 1 or 7:

LOS, the 1-bit (26) lockout subfield, if set to 1, shall signify a multisite lockout command from the interrogator indicated in IIS. LOS set to 0, shall be used to signify that no change in lockout state is commanded.

TMS, the 4-bit (29-32) tactical message subfield shall contain communications control information used by the data link avionics.

e) If DI = 7:

RRS, the 4-bit (21-24) reply request subfield in SD shall give the BDS2 code of a requested Comm-B reply.

Bits 25, 27 and 28 are not assigned.

f) If DI = 2:

TCS, the 3-bit (21-23) type control subfield in SD shall control the position type used by the transponder. The following codes have been assigned:

0 signifies no position type command
1 signifies use surface position type for the next 15 seconds
2 signifies use surface position type for the next 60 seconds
3 signifies cancel surface type command
4-7 not assigned.

RCS, the 3-bit (24-26) rate control subfield in SD shall control the squitter rate of the transponder when it is reporting the surface format. This subfield shall have no effect on the transponder squitter rate when it is reporting the airborne position type. The following codes have been assigned:

0 signifies no surface squitter rate command
1 signifies report high surface squitter rate for 60 seconds
2 signifies report low surface squitter rate for 60 seconds
3 signifies suppress all surface squitters for 60 seconds
4 signifies suppress all surface squitters for 120 seconds
5-7 not assigned.

Note.— The definition of high and low squitter rate is given in 3.1.2.8.6.4.3.

SAS, the 2-bit (27-28) surface antenna subfield in SD shall control the selection of the transponder diversity antenna that is used for (1) the extended squitter when ~~it~~ the transponder is reporting the surface format, and (2) the acquisition squitter when the transponder is reporting the on-the-ground status. This subfield shall have no effect on the transponder diversity antenna selection when it is reporting the airborne ~~position~~ status ~~type~~. The following codes have been assigned:

0 signifies no antenna command
1 signifies alternate top and bottom antennas for 120 seconds
2 signifies use bottom antenna for 120 seconds
3 signifies return to the default.

Note.— The top antenna is the default condition (3.1.2.8.6.5).

g) If DI = 3:

SIS, the 6-bit (17-22) surveillance identifier subfield in SD shall contain an assigned surveillance identifier code of the interrogator (3.1.2.5.2.1.2.~~2~~4).

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3.1.2.6.5.1 *FS: Flight status.* This 3-bit (6-8) downlink field shall contain the following information:

Coding	
0	signifies no alert and no SPI, aircraft is airborne
1	signifies no alert and no SPI, aircraft is on the ground
2	signifies alert, no SPI, aircraft is airborne
3	signifies alert, no SPI, aircraft is on the ground
4	signifies alert and SPI, aircraft is airborne or on the ground
5	signifies no alert and SPI, aircraft is airborne or on the ground
6	~~not assigned~~ reserved
7	not assigned

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3.1.2.6.5.4 *AC: Altitude code.* This 13-bit (20-32) field shall contain altitude coded as follows:

a) Bit 26 is designated as the M bit, and shall be 0 if the altitude is reported in feet. M equals 1 shall be reserved to indicate that the altitude reporting is in metric units.

b) If M equals 0, then bit 28 is designated as the Q bit. Q equals 0 shall be used to indicate that the altitude is reported in 100-foot increments. Q equals 1 shall be used to indicate that the altitude is reported in 25-foot increments.

c) If the M bit (bit 26) and the Q bit (bit 28) equal 0, the altitude shall be coded according to the pattern for Mode C replies of 3.1.1.7.12.2.3. Starting with bit 20 the sequence shall be C1, A1, C2, A2, C4, A4, ZERO, B1, ZERO, B2, D2, B4, D4.

d) If the M bit equals 0 and the Q bit equals 1, the 11-bit field represented by bits 20 to 25, 27 and 29 to 32 shall represent a binary coded field with a least significant bit (LSB) of 25 ft. The binary value of the positive decimal integer "N" shall be encoded to report pressure-altitude in the range [(25 N — 1 000) plus or minus 12.5 ft]. The coding of ~~3.1.1.7.12.2.3~~ 3.1.2.6.5.4 c) shall be used to report pressure-altitude above 50 187.5 ft.

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f) 0 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 invalid.

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3.1.2.6.10.1.1.3 *Termination of the permanent alert condition.* The permanent alert condition shall be terminated and replaced by a temporary alert condition when the Mode A identity code is set to a value other than 7500, 7600 or 7700.

3.1.2.6.10.1.2 *Ground report.* The on-the-ground status of the aircraft shall be reported in the FS field and the VS field (3.1.2.8.2.1) and the CA field (3.1.2.8.1.1). 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 (3.1.2.10.5.1.3), 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).

3.1.2.6.10.1.3 *Special position identification (SPI).* An equivalent of the SPI pulse shall be transmitted by Mode S transponders in the FS field and the surveillance status subfield (SSS) when manually activated. This pulse shall be transmitted for T_I seconds after initiation (3.1.1.6.3, 3.1.1.7.13 and 3.1.2.8.6.3.1.1).

Note.— The value of T_1 is given in 3.1.2.10.3.9.

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3.1.2.6.10.2.2 Data link capability report. The data link capability report shall provide the interrogator with a description of the data link capability of the Mode S installation. The report shall be obtained by a ground-initiated Comm-B reply in response to an interrogation containing RR equals 17 and DI is not equal to 7 or DI equals 7 and RRS equals 0 (3.1.2.6.11.2). The definition of this register is described in 5.2.9.2 of Volume III to Annex 10.

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3.1.2.6.10.2.2.2 *Updating of the data link capability report.* The transponder shall, at intervals not exceeding four seconds, compare the current data link capability status with that last reported and shall, if a difference is noted, initiate a revised data link capability report by Comm-B broadcast (3.1.2.6.11.4) for BDS1 = 1 (33-36) and BDS 2 = 0 (37-40). The transponder shall initiate, generate and transmit the revised capability report even if the aircraft data link capability is degraded or lost. The transponder shall set the BDS code for the data link capability report.

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

3.1.2.6.10.3 *Validation of declared on-the-ground status*

Note.— 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. If the aircraft is equipped to report extended squitter messages, the function that formats these messages may have information available to validate that an aircraft reporting "on-the-ground" is actually airborne.

3.1.2.6.10.3.1 Aircraft with an automatic means for determining the on-the-ground condition that are equipped to format extended squitter messages shall perform the following validation check:

If the automatically determined air/ground status is not available or is "airborne", no validation shall be performed. If the automatically determined air/ground status is available and "on-the-ground" condition is being reported, the air/ground status shall be overridden and changed to "airborne" if the conditions given for the vehicle category in Table 3-5A are satisfied.

Note.— While this test is only required for aircraft that are equipped to format extended squitter messages, this feature is desirable for all aircraft.

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3.1.2.6.11.2 *Ground-initiated Comm-B*

3.1.2.6.11.2.1 *Comm-B data selector, BDS.* The 8-bit BDS code shall determine the register whose contents shall be transferred in the MB field of the Comm-B reply. It shall be expressed in two groups of 4 bits each, BDS1 (most significant 4 bits) and BDS2 (least significant 4 bits).

Note 1.— The ~~GICB~~ transponder register allocation is specified in Annex 10, Volume III, Part I, Chapter 5, Table 5-24.

Note 2.— ~~The only BDS codes defined in this section are those for aircraft identification (3.1.2.9.1.2) and for data link capability reporting (3.1.2.6.10.2.2)~~ The only registers defined in this section are those for aircraft identification (3.1.2.9.1.2), datalink capability reporting (3.1.2.6.10.2.2), extended squitter (3.1.2.8.6.2) and downlink aircraft parameters (DAPs) (3.1.2.10.5.2.3).

Table 3-5A. Validation of on-the-ground status

Determination of airborne status					
A/V category	**Ground Speed**		**Airspeed**		**Radio Altitude**
No information	No change to on-the-ground status				
Weight < 15 500 lbs (7 031 kg)	No change to on-the-ground status				
Weight ≥15 500 lbs (7 031 kg)	>100 knots	or	>100 knots	or	>50 feet
High performance (>5 g acceleration and >400 knots)	>100 knots	or	>100 knots	or	>50 feet
Rotorcraft	No change to on-the-ground status				

. . .

3.1.2.6.11.4.6 The data formats for broadcast Comm-B shall be as specfried in Appendix 1 to Chapter 5 of Annex 10, Volume III, Part I.

. . .

3.1.2.8.5.2 *Acquisition 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 of no greater than 15 milliseconds relative to the previous acquisition squitter, with the following exceptions:

a) the scheduled acquisition squitter shall be delayed if the transponder is in a transaction cycle (3.1.2.4.1);

b) the acquisition squitter shall be delayed if an extended squitter is in process;

c) the scheduled acquisition squitter shall be delayed if a mutual suppression interface is active (see Note 1 below); or

d) acquisition squitters shall only be transmitted on the surface if the transponder is not reporting the surface position type of Mode S extended squitter.

. . .

3.1.2.8.5.3 *Acquisition squitter antenna selection.* Transponders operating with antenna diversity (3.1.2.10.4) shall transmit acquisition squitters as follows:

a) when airborne (3.1.2.8.6.7), the transponder shall transmit acquisition squitters alternately from the two antennas; and

b) when on the surface (3.1.2.8.6.7), the transponder shall transmit acquisition squitters under control of SAS (3.1.2.6.1.4.1 f)). In the absence of any SAS commands, use of the top antenna only shall be the default.

. . .

3.1.2.8.6.2 *ME: Message, extended squitter.* This 56-bit (33-88) downlink field in DF = 17 shall be used to transmit broadcast messages. The formats and update rates for each register used to support extended squitter (BDS 0,5; BDS 0,6; BDS 0,7; BDS 0,8; BDS 0,9; BDS 0,A) shall be as defined in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5.

Note.— Guidance material on transponder register formats and data sources is included in the Manual on Mode S Specific Services *(Doc 9688).*

. . .

3.1.2.8.6.3.1.2 *ACS, altitude code subfield in ME.* Under control of ATS (3.1.2.8.6.3.1.3), the transponder shall report either navigation-derived altitude, or the barometric altitude code in this 12-bit (41-52) subfield of ME when ME contains an airborne position report. When barometric altitude is reported, t~~T~~he contents of the ACS shall be as specified for the 13-bit AC field (3.1.2.6.5.4) except that the M-bit (bit 26) shall be omitted.

3.1.2.8.6.3.1.3 *Control of ACS reporting.* Transponder reporting of altitude data in ACS shall ~~take place when the 1-bit altitude type subfield (ATS) (3.1.2.8.6.8.2) has the value of 0~~ depend on the altitude type subfield (ATS) as specified in 3.1.2.8.6.8.2. Transponder ~~reporting~~ insertion of barometric altitude data in ACS shall be inhibited when ATS has the value 1.

. . .

3.1.2.8.6.4.1 *Initialization*. At power up initialization, the transponder shall commence operation in a mode in which it broadcasts only acquisition squitters (3.1.2.8.5). The transponder shall initiate the broadcast of extended squitters for airborne position, surface position, airborne velocity and aircraft identification when data are inserted into ~~GICB~~ transponder registers 05, 06, 09 and 08 {HEX}, respectively. This determination shall be made individually for each squitter type. 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 unless the acquisition squitter is inhibited (2.1.5.4). Acquisition squitters shall always be reported if ~~extended~~ position or velocity extended squitters are not reported.

Note 1.— This suppresses the transmission of ~~long~~ extended squitters from aircraft that are unable to report position, velocity or identity. If input to the register for a squitter type stops for 60 seconds, broadcast of that extended squitter type will be discontinued until data insertion is resumed.

Note 2.— After timeout (3.1.2.8.6.6), this squitter type may contain an ME field of all zeroes.

3.1.2.8.6.4.2 *Airborne position squitter rate.* Airborne position squitter transmissions shall be emitted when the aircraft is airborne (3.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne position squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.3 *Surface position squitter rate.* Surface position squitter transmissions shall be emitted when the aircraft is on the surface (3.1.2.8.6.7) using one of two rates depending upon whether the high or low squitter rate has been selected (3.1.2.8.6.9). 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 of 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 of no greater than 15 milliseconds relative to the previous surface position squitter (termed the low rate). Exceptions to these transmission rates are specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.4 *Aircraft identification squitter rate.* Aircraft identification 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 of no greater than 15 milliseconds relative to the previous identification squitter when the aircraft is reporting the airborne position squitter type, or when the aircraft is reporting the surface position squitter type and the high surface squitter rate has been selected. When the surface position squitter type is being reported at the low surface rate, the aircraft identification squitter shall be emitted at random intervals that are uniformly distributed over the range of ~~9.6~~ 9.8 to ~~10.4~~ 10.2 seconds using a time quantization of no greater than 15 milliseconds relative to the previous identification squitter. Exceptions to these transmission rates are specified in 3.1.2.8.6.4.7.

3.1.2.8.6.4.5 *Airborne velocity squitter rate.* Airborne velocity squitter transmissions shall be emitted when the aircraft is airborne (3.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne velocity squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

. . .

3.1.2.8.6.4.7 *Delayed transmission.* Extended squitter transmission shall be delayed in the following circumstances:

a) if the transponder is in a transaction cycle (3.1.2.4.1);

b) if an acquisition or another type of extended squitter is in process; or

c) if a mutual suppression interface is active.

The delayed squitter shall be transmitted as soon as the transponder becomes available.

. . .

3.1.2.8.6.6 *Register time-out*. The transponder shall clear all 56-bits of the airborne position, surface position, squitter status and airborne velocity information ~~GICB~~ transponder registers 05, 06, 07 and 09 {HEX} if these registers are not updated within two seconds of the previous update. This time-out shall be determined separately for each of these registers. Termination of extended squitter broadcast shall be as specified in Annex 10, Volume III, Part I.

. . .

3.1.2.8.6.8.1 *TRS, transmission rate subfield in MB.* The transponder shall report the capability of the aircraft to automatically determine its surface squitter rate and its current squitter rate in this 2-bit (33, 34) subfield of MB.

Coding

0 signifies no capability to automatically determine surface squitter rate
1 signifies that the high surface squitter rate has been selected
2 signifies that the low surface squitter rate has been selected
3 unassigned

Note 1.— High and low squitter rate 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. For details of how "moving" is determined, see Table A-2.7 in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5.

3.1.2.8.6.8.2 *ATS, altitude type subfield in MB*. The transponder shall report the type of altitude being provided in the airborne position extended squitter in this 1-bit (35) subfield of MB when the reply contains the contents of GICB transponder register 07 {HEX}.

Coding

0 signifies that barometric altitude is shall be being reported in the ACS (3.1.2.8.6.3.1.2) of transponder register 05 {HEX}.

1 signifies that navigation-derived height is altitude shall be being reported in the ACS (3.1.2.8.6.3.1.2) of transponder register 05 {HEX}.

Note.— For details of the contents of transponder registers 05 {HEX} and 07 {HEX} see Annex 10, Volume III, Part I, Appendix 1 to Chapter 5.

3.1.2.8.6.9 *Surface squitter rate control*. Surface squitter rate shall be determined as follows:

a) once per second the contents of the TRS 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 TRS shall be subject to being overridden by commands received via RCS (3.1.2.6.1.4.1 f)). 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 time-out of the prior period; and

c) after time-out and in the absence of RCS codes 1 and 2, control shall return to TRS.

3.1.2.8.6.10 *Latitude/longitude coding using compact position reporting (CPR)*. Mode S extended squitter uses compact position reporting (CPR) to encode latitude and longitude efficiently into messages. The method used to encode/decode CPR shall comply with the equations in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5.

Insert new text as follows:

3.1.2.8.7 *EXTENDED SQUITTER/NON TRANSPONDER (ES/NT), DOWNLINK FORMAT 18*

10010	CF:3	AA:24	ME:56	PI:24

Note.— This format supports the broadcast of extended squitter ADS-B messages by non-transponder devices, i. e. they are not incorporated into a Mode S transponder. A separate format is used to clearly identify this non-transponder case to prevent ACAS II or extended squitter ground stations from attempting to interrogate these devices.

3.1.2.8.7.1 *ES/NT format.* The format used for ES/NT shall be a 112-bit downlink format (DF = 18) containing the following fields:

Field	*Reference*
DF downlink format	3.1.2.3.2.1.2
CF control field	3.1.2.8.7.2
AA address, announced	3.1.2.5.2.2.2
ME message, extended squitter	3.1.2.8.6.2
PI parity/interrogator identifier	3.1.2.3.2.1.4

The PI field shall be encoded with II or SI equal to zero.

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

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

3.1.2.8.7.3 **ES/NT squitter types**

3.1.2.8.7.3.1 *Airborne position squitter.* The airborne position type ES/NT shall use format DF = 18 with the format for register 05 {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.3.2 *Surface position squitter.* The surface position type ES/NT shall use format DF = 18 with the format for register 06 {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.3.3 *Aircraft identification squitter.* The aircraft identification type ES/NT shall use format DF = 18 with the format for register 08 {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.3.4 *Airborne velocity squitter.* The airborne velocity type ES/NT shall use format DF = 18 with the format for register 09 {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field

3.1.2.8.7.3.5 *Event-driven squitter.* The event-driven type ES/NT shall use format DF = 18 with the format for register 0A {HEX} as defined in 3.1.2.8.6.2 inserted in the ME field.

3.1.2.8.7.4 **ES/NT squitter rate**

3.1.2.8.7.4.1 *Initialization.* At power up initialization, the non-transponder device shall commence operation in a mode in which it does not broadcast any squitters . The non-transponder device shall initiate the broadcast of ES/NT squitters for airborne position, surface position, airborne velocity and aircraft identification when data are available for inclusion in the ME field of these squitter types. This determination shall be made individually for each squitter type. When ES/NT squitters are broadcast, transmission rates shall be as indicated in the paragraphs 3.1.2.8.6.4.2 to 3.1.2.8.6.4.6.

Note 1.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity. If input to the register for squitter types stops for 60 seconds, broadcast for this extended squitter type will cease until data insertion resumes.

Note 2.— After timeout (3.1.2.8.7.6) this squitter type may contain an ME field of all zeros.

3.1.2.8.7.4.2 *Delayed transmission.* ES/NT squitter transmission shall be delayed if the non-transponder device is busy broadcasting one of the other squitter types.

3.1.2.8.7.4.2.1 The delayed squitter shall be transmitted as soon as the non-transponder device becomes available.

3.1.2.8.7.5 *ES/NT antenna selection.* Non-transponder devices operating with antenna diversity (3.1.2.10.4) shall transmit ES/NT squitters as follows:

a) when airborne (3.1.2.8.6.7), the non-transponder device shall transmit each type of ES/NT squitter alternately from the two antennas; and

b) when on the surface (3.1.2.8.6.7), the non-transponder device shall transmit ES/NT squitters using the top antenna.

3.1.2.8.7.6 *Register timeout.* The non-transponder device shall clear all 56 bits of the airborne position, surface position and velocity registers used for these messages if these registers are not updated within two seconds of the previous update. This timeout shall be determined separately for each of these registers. Termination of extended squitter broadcast shall be as specified in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5, paragraph 2.4.3.

Note.— These registers are cleared to prevent the reporting of outdated position and velocity information.

3.1.2.8.7.7 *Airborne/surface state determination.* Aircraft with an automatic means of determining on-the-ground condition shall use this input to select whether to report the airborne or surface message types. Aircraft without such means shall report the airborne type messages.

3.1.2.8.7.8 *Surface squitter rate control.* Once per second the algorithm for aircraft motion specified in Table A2-7 in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5 shall be executed. The surface squitter rate shall be set according to the results of this algorithm.

3.1.2.8.8 *EXTENDED SQUITTER MILITARY APPLICATION, DOWNLINK FORMAT 19*

10011	AF:3	

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.

3.1.2.8.8.1 *Military format.* The format used for DF=19 shall be a 112-bit downlink format containing the following fields:

Field	*Reference*
DF downlink format	3.1.2.3.2.1.2
AF control field	3.1.2.8.8.2

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

Code 0 to 7 = Reserved

3.1.2.8.9 *EXTENDED SQUITTER MAXIMUM TRANSMISSION RATE*

3.1.2.8.9.1 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.

End of new text.

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3.1.2.10.3.10 *Inhibition of replies.* Replies to Mode A/C/S all-call and Mode S-only all-call interrogations shall always be inhibited when the aircraft ~~is on the ground~~ declares the on-the-ground state. It shall not be possible to inhibit replies to discretely addressed Mode S interrogations~~, or acquisition squitter transmissions,~~ regardless of whether the aircraft is airborne or on the ground.

3.1.2.10.3.10.1 **Recommendation.—** *Aircraft should provide means to determine the on-the-ground state automatically and provide that information to the transponder.*

3.1.2.10.3.10.2 **Recommendation.—** *Mode A/C replies should be inhibited when the aircraft is on the ground to prevent interference when in close proximity to an interrogator or other aircraft.*

Note.— ~~In some installations Mode A/C replies may be inhibited when the aircraft is on the ground to prevent interference when in close proximity to an interrogator or other aircraft.~~ Mode S discretely addressed interrogations do not give rise to such interference and may be required for data link communications with aircraft on the airport surface. Acquisition squitter transmissions may be used for passive surveillance of aircraft on the airport surface.

3.1.2.10.3.10.3 *Inhibition of squitter transmissions.* It shall not be possible to inhibit extended squitter transmissions except as specified in 3.1.2.8.6 or acquisition squitter transmissions except as specified in 3.1.2.8.5 regardless of whether the aircraft is airborne or on the ground.

Note.— For additional information on squitter inhibition see the Manual of the Secondary Surveillance Radar (SSR) Systems *(Doc 9684).*

3.1.2.10.4 *Transponder antenna system and diversity operation.* Mode S transponders equipped for diversity operation shall have two RF ports for operation with two antennas, one antenna on the top and the other on the bottom of the aircraft's fuselage. The received signal from one of the antennas shall be selected for acceptance and the reply shall be transmitted from the selected antenna only.

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3.1.2.10.5.2.2.2.1 **Recommendation.—** *Level 3 and level 4 transponders should be able to accept at least two complete sixteen segment uplink ELMs in a 250 millisecond interval.*

3.1.2.10.5.2.3 *Data formats for downlink aircraft parameter (DAP) standard length transactions.* The downlink standard length transaction interface is used to deliver downlink aircraft parameters (DAPs) to the transponder which makes them available to the ground. Each DAP is packed into the Comm-B format (‘MB’ field) and can be extracted using either the ground-initiated Comm-B (GICB) protocol, or using MSP downlink channel 3 via the dataflash application (as defined in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5). The formats and update rates of each register used to support DAPs (BDS 1,7; BDS 1,8 to 1,C; BDS 1, D to 1,F; BDS 4,0; BDS 5,0; BDS 6,0) shall be as defined in Annex 10, Volume III, Part I, Appendix 1 to Chapter 5.

Note.— Guidance material on transponder register formats and data sources is included in the Manual on Mode S Specific Services *(Doc 9688).*

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3.1.2.11.1.3.2 Additionally, for a Mode S interrogator ~~operating with an E-scan~~ that has overlapping coverage with the sidelobes of any other Mode S interrogator, ~~or is operating with a rotating antenna,~~ the transmission rate for selective interrogations shall be:

a) less than 1 200 per second averaged over a 4-second interval; and

b) less than 1 800 per second averaged over a 1-second interval.

Note.— Typical minimum distance to ensure sidelobe separation between interrogators is ~~25~~ 35 km.

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CHAPTER 4. AIRBORNE COLLISION AVOIDANCE SYSTEM

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4.2 ACAS I GENERAL PROVISIONS AND CHARACTERISTICS

4.2.1 *Functional requirements.* ACAS I shall perform the following functions:

a) surveillance of nearby SSR transponder-equipped aircraft; and

b) provide indications to the flight crew identifying the approximate position of nearby aircraft as an aid to visual acquisition.

Note.— ACAS I is intended to operate using Mode A/C interrogations only. Furthermore, it does not co-ordinate with other ACAS. Therefore, a Mode S transponder is not required as a part of an ACAS I installation.

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4.2.3.3.3 *Mode A/C ACAS I interference limits.* The interrogator power shall not exceed the following limits:

n_a	*Upper limit for* $\{\sum_{k=1}^{k_t} P_a(k)\}$	
	If $f_r \leq = 240$	*If* $f_r > 240$
0	250	118
1	250	113
2	250	108
3	250	103
4	250	98
5	250	94
6	250	89
7	250	84
8	250	79
9	250	74
10	245	70
11	228	65
12	210	60
13	193	55
14	175	50
15	158	45
16	144	41
17	126	36
18	109	31
19	91	26
20	74	21
21	60	17
$\geq$22	42	12

where:

n_a = number of operating ACAS II and ACAS III equipped aircraft near own (based on ACAS broadcasts received with a transponder receiver threshold of –74 dBm);

{ } = average value of the expression within the brackets over last ~~16~~ 8 interrogation cycles;

$P_a(k)$ = peak power radiated from the antenna in all directions of the pulse having the largest amplitude in the group of pulses comprising a single interrogation during the *k*th Mode A/C interrogation in a 1 s interrogation cycle, W;

k = index number for Mode A/C interrogations, $k = 1, 2, ..., k_t$;

k_t = number of Mode A/C interrogations transmitted in a 1 s interrogation cycle;

f_r = Mode A/C reply rate of own transponder.

4.2.2.3.4 *Mode S ACAS I interference limits.* An ACAS I that uses Mode S interrogations shall not cause greater interference effects than an ACAS I using Mode A/C interrogations only.

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4.3.7.1.2.1 *Detection.* ~~ACAS shall detect the presence and determine the address of Mode S-equipped aircraft by monitoring at 1 090 MHz for Mode S all-call replies (DF = 11). The altitude of the Mode S-equipped aircraft shall then be determined either by passively monitoring replies that contain altitude (DF = 0, 4, 16 or 20) received from that aircraft or, if necessary, by interrogating the aircraft with UF = 0.~~ ACAS shall monitor 1 090 MHz for Mode S acquisition squitters (DF = 11). ACAS shall detect the presence and determine the address of Mode S-equipped aircraft using their Mode S acquisition squitters (DF = 11) or extended squitters (DF = 17).

Note 1.— It is acceptable to acquire individual aircraft using either acquisition or extended squitters (DF = 11 or DF = 17), and to monitor for both squitters. However, ACAS must monitor for acquisition squitters because, at any time, not all aircraft will transmit the extended squitter.

Note 2.— If, in the future, it becomes permitted for aircraft not to transmit the acquisition squitter, relying instead on continual transmission of the extended squitter, it would become essential for all ACAS units to monitor for both the acquisition and the extended squitters.

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4.3.8.4.2.2.2 *Subfields in MB for the data link capability report.* When BDS1 = 1 and BDS2 = 0, the following bit patterns shall be provided to the transponder for its data link capability report:

Bit	*Coding*
48	0 ACAS failed or on standby
	1 ACAS operating

69	0 ACAS II
	1 ACAS III
70	0 ACAS generating TAs only
	1 ACAS generating TAs and RAs
71	0 ACAS not fitted
	1 ACAS fitted
72	0 Hybrid surveillance not fitted
	1 Hybrid surveillance fitted

Note 1.— A summary of the MB subfields for the data link capability report structure is described in Chapter 3, 3.1.2.6.10.2.2.

Note 2.— The use of hybrid surveillance to limit ACAS active interrogations is described in 4.5.1. The ability only to support decoding of DF = 17 extended squitter messages is not sufficient to set bit 72.

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4.3.9 ACAS equipment characteristics

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4.3.9.2.3 *ANTENNA SELECTION*

4.3.9.2.3.1 *Squitter reception.* ACAS shall be capable of receiving squitters via the top and bottom antennas.

4.3.9.2.3.2 *Interrogations.* ACAS interrogations shall not be transmitted simultaneously on both antennas.

4.3.9.3 *Pressure altitude source*. The altitude data for own aircraft provided to ACAS shall be obtained from the source that provides the basis for own Mode C or Mode S reports and they shall be provided at the finest quantization available.

4.3.9.3.1 **Recommendation.—** *A source providing a resolution finer than 7.62 m (25 ft) should be used.*

4.3.9.3.2 Where a source providing a resolution finer than 7.62 m (25 ft) is not available, and the only altitude data available for own aircraft is Gilham encoded, at least two independent sources shall be used and compared continuously in order to detect encoding errors.

4.3.9.3.3 **Recommendation.—** *Two altitude data sources should be used and compared in order to detect errors before provision to ACAS.*

4.3.9.3.4 The provisions of 4.3.10.3 shall apply when the comparison of the two altitude data sources indicates that one of the sources is in error.

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ATTACHMENT A TO VOLUME IV

Guidance material related to airborne collision avoidance system (ACAS)

Note 1.— The following material is intended to provide guidance concerning the technical characteristics of the airborne collision avoidance system (ACAS) having vertical resolution capability (ACAS II, unless stated otherwise). ACAS SARPs are contained in Chapter 4.

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2.3.2 ALTITUDE BIT FAILURE

If the Mode C or Mode S altitude reports from the intruding aircraft or the altitude data for own aircraft contain bit errors, ACAS may develop erroneous estimates of the corresponding vertical position ~~and/~~or rate ~~of the intruder~~. These errors can have effects similar to the effects of measurement errors. Such errors are most likely to occur when the altitude data source is a Gilham encoder, and the use of Gilham encoded data for own aircraft altitude can have serious adverse consequences. When there is no alternative source than Gilham encoded data, two encoders must be used and a comparison function in the Mode S transponder used to detect errors in the altitude data before they are provided to ACAS.

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Insert new text as follows:

2.6 Potential for TCAS I systems to affect ACAS II performance

Note.— For the purpose of this material, TCAS I is defined as a system that uses SSR interrogations to provide aircrew with traffic alert warning information as an aid to the "see and avoid" principle.

Some TCAS I systems employ ACAS II interference limiting techniques with resolution advisories suppressed. These systems do no comply with ACAS I SARPs. Because ACAS II interference limiting relies on direct interaction with other ACAS II aircraft (using the ACAS broadcast and Mode S transponder replies), the presence of such TCAS I aircraft can directly influence the surveillance performance of nearby ACAS II aircraft. If such TCAS I systems are fitted to aircraft that are known to operate in close proximity to each other (e.g. rotorcraft or gliders) then the effect may reduce the surveillance range of other ACAS II aircraft, and delay the provision of collision avoidance warnings. In light of these concerns, TCAS I systems (which employ ACAS II interference limiting techniques) must not be used for aircraft which are known to operate in close proximity to each other for sustained periods of time. Care must be taken to ensure that the effect on the SSR electromagnetic environment is acceptable, since these TCAS I units may be fitted in very large numbers.

End of new text

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3.1.3.3 Mode S interrogation rates are kept low by passive detection of transponder transmissions and by interrogating once per second only those intruders that could become immediate threats. Intruders that are not likely to become immediate threats should be interrogated less frequently (i.e. once every 5 seconds). Passive address acquisition prevents unnecessary interference with other elements of the SSR and ACAS system. ACAS listens to Mode S all-call replies (DF = 11, acquisition squitter transmissions, Chapter 3, 3.1.2.8.5.1) or DF = 17, extended squitter transmissions, Chapter 3, 3.1.2.8.6.1). These may occur in response to Mode S ground station all-call interrogations or as spontaneous replies transmission (called squitters) at intervals ranging from 0.8 to 1.2 seconds for the acquisition squitter, and at shorter intervals for the extended squitter. Reception of squitters may be alternated between the top and bottom antennas. If reception is switched, it will be necessary to control the switching times to avoid undesirable synchronism with the squitters transmitted by Mode S antenna diversity transponders.

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3.1.3.7 *MODE S SURVEILLANCE INITIATION*

3.1.3.7.1 The equipment is intended to provide Mode S surveillance with a minimum of Mode S interrogations. The identity of Mode S targets is determined by passively monitoring transmissions received with DF = 11 or DF = 17. Error detection and correction is applied to the received squitters to reduce the number of addresses to be processed. The altitude of the Mode S targets from which a squitter has been received is determined by passive monitoring transmissions received with DF = 0 (short air-air surveillance replies, Chapter 3, 3.1.2.8.2) or DF = 4 (surveillance altitude replies, Chapter 3, 3.1.2.6.5) or active selective interrogations (air-air surveillance interrogation. Chapter 4, 4.3.8.4) and monitoring the corresponding air-air surveillance replies. The equipment monitors squitter and altitude replies whenever it is not transmitting, or receiving replies to, Mode S or Mode C interrogations. Each received reply is examined to determine what further action should be taken.

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3.2.3.3 Within an airspace in which ACAS aircraft are distributed between the limits of uniform-in-range to uniform-in-area, and provided that the "victim" is taken off the air for 35 microseconds by suppression or reply dead time whenever it receives an ACAS interrogation, the total "off" time caused by ACAS interrogations will then never exceed 1 per cent. Measurements and simulations indicate that the total "off" time can be higher than 1 per cent in high-density terminal areas because of ACAS aircraft distributions that are beyond the region defined by uniform-in-area to uniform-in-range and because of a Mode S transponder recovery time to certain interrogations that is expected to be greater than 35 microseconds. The second term on the right-hand side of this inequality limits the maximum value of the interrogation power-rate product for ACAS II, regardless of n_a, in order to allow a portion of the total interference limiting allocation to be used by ACAS I. The term, which is matched to the ACAS distribution by the value of α in the denominator, ensures that an individual ACAS II unit never transmits more average power than it would if there were approximately 26 other ACAS II nearby distributed uniformly-in-area or approximately 12 6 other ACAS II nearby distributed nearly uniformly-in-range.

3.2.3.3.1 High-density terminal areas will suffer from higher loads due to violation of the 1 per cent estimate at approximately 14.8 - 18.5 km (8 - 10 NM) from touch-down. To ensure sufficient surveillance performance for both, ACAS and ground surveillance systems, in such areas ACAS flying below 610 m

(2 000 ft) AGL include also ACAS II and ACAS III operating on ground in the calculation of n_b and n_c. This value was chosen for practical reasons:

a) the use of a radio altimeter allows sufficient measurement accuracy at and below 610 m (2 000 ft); and

b) assuming aircraft are approaching on an ILS glide path. In that case, 610 m (2 000 ft) AGL corresponds to a distance of approximately 11.2 km (6 NM) from an airport.

New approach procedures (e.g. based on MLS or GNSS) may require additional considerations to limit interference. And even with ILS approach, it is recommended to establish procedures switching ACAS II and ACAS III to "stand-by" while the aircraft is not on an active runway.

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3.4.4.2 Error correction decoding is to be used for the following replies: DF = 11 all-call replies, DF = 0 short air-air surveillance replies, and DF = 16 long air-air surveillance replies (both acquisition and non-acquisition). In addition, passive monitoring of DF = 4 short surveillance altitude replies requires error correction decoding.

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3.5.8.10 *OTHER CAUSES OF INDUCED CLOSE ENCOUNTERS*

3.5.8.10.1 *Altimetry errors.* The altitude separation parameter representing the separation goal (A_l) must include an allowance for altimetry error that is sufficient to give a high probability of not causing an ACAS-equipped aircraft to provoke a close encounter where none really existed. For gross altimetry errors, however, there remains a low probability that a close encounter will be induced when the original separation is adequate. Similarly, there is a low probability that ACAS will be unable to resolve a close encounter due to altimetry error.

3.5.8.10.1.1 The use of Gilham encoded data for either aircraft is a particular cause of altitude report errors and induced close encounters have resulted. In the case of own aircraft, such errors can be prevented by using an altitude source that has not been Gilham encoded.

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4.1.2 ALTITUDE TRACKING

4.1.2.1 *Sources of altitude data.* Intruder aircraft's altitude is obtained from intruder Mode C or Mode S reports. Own aircraft's altitude is obtained from the source that provides the basis for own Mode C or Mode S reports and is ~~used~~ required to be at the finest quantization available.

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4.3.2 *Criteria for threat declaration.* An intruder becomes a threat if and only if both the following apply on the same cycle:

a) the range test gives a positive result; and

b) ~~the altitude test gives a positive result.~~either:

1) the altitude test gives a positive result; or

2) an altitude-crossing RAC has been received from the threat.

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4.4 Generation of RAs

4.4.1 RA types are defined in Chapter 4, 4.1.

4.4.2 Delay in RA generation

Note.— An RA will be generated for all threats except in the circumstances described here or for co-ordination purposes.

The reference logic does not generate a new RA or modify an existing RA for a new threat when any of the following conditions are satisfied:

a) ~~the altitude separation test (4.4.2.1) gives a negative result; or~~an altitude-crossing RAC has not been received from the threat; and

b) ~~confidence in the tracked altitude rate of the intruder is "low" and no resolution manoeuvre would provide a predicted separation of at least A_t (4.4.2.2), whether the threat had an altitude rate equal to the upper altitude rate bound, to the lower altitude rate bound, or to any altitude rate between these bounds (4.1.2.3.4); or~~ either:

1) the altitude separation test (4.4.2.1) gives a negative result; or

2) confidence in the tracked altitude rate of the intruder is "low" and no resolution manoeuvre would provide a predicted separation of at least A_t (4.4.2.2), whether the threat had an altitude rate equal to the upper altitude rate bound, to the lower altitude rate bound, or to any altitude rate between these bounds (4.1.3.3.4); or

3) there is "low" confidence in the threat's tracked altitude rate, the current altitude separation is greater than 46 m (150 ft), and the RA that would be selected against the threat when considered separately from other possible threats, would be altitude crossing.

c) there is "low" confidence in the threat's tracked altitude rate, the current altitude separation is greater than 46 m (150 ft), and the RA that would be selected against the threat when considered separately from other possible threats, would be altitude crossing.

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