SURICG/9 – **IP/03**
Agenda Item 7
07-10/05/24

International Civil Aviation Organization

Ninth Meeting of the Surveillance Implementation Coordination Group (SURICG/9)

Bangkok, Thailand, 7 – 10 May 2024

Agenda Item 7: Update on surveillance activities and explore potential cooperation opportunity

PROPOSAL FOR AMENDMENT (PFA) TO ANNEX 10, VOLUME IV, ENDORSED BY THE SURVEILLANCE PANEL

(Presented by Co-chair)

SUMMARY

The fifth meeting of the Surveillance Panel took place in September 2023 and endorsed Proposal for Amendment to Annex 10 Volume IV. This paper highlights the amendments that are of interest to the SURICG.

1. INTRODUCTION

1.1 The Surveillance Panel (SP) was tasked by the Air Navigation Commission to undertake specific studies and to develop technical and operational ICAO provisions for aeronautical surveillance systems, collision avoidance systems and their applications as outlined in the Global Air Navigation Plan.

1.2 This paper highlights the amendments on Annex 10 Volume IV that are of interest to the SURICG.

2. DISCUSSION

Summary of Changes

2.1 The fifth meeting of the SP endorsed the proposal for amendment as attached in **Annex A**. The proposal contains updates to existing provisions and clarifications including:

a) updates to transponder requirements for compatibility with the new 1 090 MHz extended squitter ADS-B version 3 format as detailed in RTCA/EUROCAE avionics standards.

b) technical provisions for the efficient use of the 1 090 MHz radio frequency (RF).

c) some updates to existing provisions, editorial changes and clarifications in light of new developments and operational experience relating to surveillance systems.

d) modifications to the signals in space requirements to increase clarity and to align the ATCRBS and Mode S requirements. Additionally, to modify the SARPS from specifying requirements for ATCRBS and Mode S systems to requirements for ATCRBS and Mode S capabilities.

e) Introduction of Interference Tolerance Criteria
There are new systems seeking to operate in spectrum closer to the 1030/1090 MHz frequencies. Aeronautical surveillance and collision avoidance receivers currently have no defined interference tolerance criterion, which is necessary to define the level of interference those receivers should expect to tolerate from new RF systems as well as criterion on which to base compatibility studies to protect the performance of surveillance and collision avoidance systems.

f) Clarifications on II and SI Codes for Lockout Override, Supplementary, and Non-All Call Acquisition.

g) Technical provisions describing II/SI code operation that is required to be used by Mode S radars to start using SI code before all aircraft are SI code capable.

Highlights (IC for ADS-B AND M-LAT)

2.2 It was recalled that during Mode S DAPs WG/2, there was a discussion on such interrogators that come with ADS-B stations need to be assigned with a distinct IC. It was not clear from the ICAO materials then which values could be used although EUROCONTROL has been using II = 0. The Surveillance Panel (SP) Aeronautical Surveillance Working Group (ASWG) therefore worked on the amendments to address, *inter alia*, the ICs that can be assigned for interrogators not using Mode S all-call interrogations, lockout command and the multisite data-link protocols.

2.3 The usage of IC code and IIS field were clarified. The rationale for the clarifications is as follows:
Lockout override should be permitted on any interrogator code (IC) and not limited to II=0, as the transponder will disregard the IC. Supplementary acquisition, which is limited by definition, should also be allowed on any IC and not limited to II = 0. Systems that do not use Mode S-only all-call interrogations, lockout protocol, or multisite protocol should be able to use any IC and not be limited to II=0 if not assigned an IC. For example, multilateration systems may desire to use certain ICs for improved monitoring.

2.4 Section 3.1.2.5.2.1.2.3 of Annex 10 Vol 4 states that II Code = 0 **shall only be used** for supplementary acquisition in conjunction with acquisition based on lockout override. Although it is in a section about all-call interrogations (3.1.2.5.2.1 *Mode S-only all-call interrogation, uplink format 11)* it was proposed to remove the restriction to avoid the confusion with the use of II=0 in the interrogations transmitted by MLAT interrogators.

> 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~~ multiple II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.
>
> *Note 1.— 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 2.— Lockout on the II code value of 0 is used for non-selective all-call lockout (3.1.2.6.9.2).*

2.5 Amendments were made to Section 3.1.2.6.1.4.1 and 3.1.2.11.6 of Annex 10 Vol 4 to show that there is no need of coordination for interrogators not using lockout or multisite datalink protocols. Coordination of IC codes may help aid understanding of RF contribution.

> 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 the ~~an assigned~~ identifier code of the interrogator (3.1.2.5.2.1.2.3).

Note.— The IIS is intended to match the II code used by the interrogator in the Mode S-only all-call interrogation (3.1.2.5.2.1). Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC in the IIS fields of their selective interrogations without coordination with neighbouring systems. The use of coordinated values differentiates interrogations transmitted by the different systems operating in the same area and facilitates the understanding of their respective contribution to the 1090 MHz environment.

…

g) If DI = 3:

SIS, the 6-bit (17-22) surveillance identifier subfield in SD shall contain ~~an assigned~~ the surveillance identifier code of the interrogator (3.1.2.5.2.1.2.4).

Note.— The SIS is intended to match the SI code used by the interrogator in the Mode S-only all-call interrogation (3.1.2.5.2.1). Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC in the SIS fields of their selective interrogations without coordination with neighbouring systems. The use of coordinated values differentiates interrogations transmitted by the different systems operating in the same area and facilitates the understanding of their respective contribution to the 1090 MHz environment.

LSS, the 1-bit (23) lockout surveillance subfield, if set to 1, shall signify a multisite lockout command from the interrogator indicated in SIS. If set to 0, LSS shall signify that no change in lockout state is commanded.

…

3.1.2.11.6 *Lockout coordination.* A Mode S interrogator shall not be operated using all-call lockout until coordination has been achieved with all other operating Mode S interrogators having any overlapping coverage volume in order to ensure that no interrogator can be denied the acquisition of Mode S-equipped aircraft. If coordination is not possible due to system designs (for example, a mobile interrogator), the interrogator shall either use passive means of acquisition or operate using lockout override (3.1.2.5.2.1.4) with supplementary acquisition (3.1.2.5.2.1.5).

Note 1.— This coordination may be via ground network or by the allocation of interrogator ~~identifier (II)~~ codes and will involve regional agreements where coverage overlaps international boundaries.

Note 2.— Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite datalink protocol can use any IC value in the IIS or SIS fields of their selective interrogations without a need for coordination with neighbouring systems.

Highlights (II/SI Code Operation)

2.6 ICAO Annex 10 Vol. IV section 2.1.5.1.7.1 specifies that all Mode S transponders shall be SI code capable since 1 January 2005. However, this is not yet the case and it may take a very long time before all aircraft are able because aircraft are not all subject to ICAO provisions (military, local small general aviation, …).

2.7 SI codes cannot be used without having the necessary capabilities in Mode S interrogator to continue detecting the old transponders not supporting SI code. It will take years possibly decades to have all transponders supporting SI codes.

2.8 To facilitate the implementation of SI codes by States and the allocation of SI codes by ICAO Regional Offices with the current mix of aircraft SI code capability, it is necessary to use a special mode of operation known as the II/SI mode of operation.

2.9 The II/SI code operation is a specific mode of operation that allows interrogators operating on SI code to acquire Mode S II-only transponders on the matching II code. It was necessary to use that mode of operation in ICAO EUR Region to allocate SI codes to radars before all transponders are SI code capable. This mode of operation has been made mandatory in EU regulation. It is included in the European Mode S radar specification (EMS 4.0).

2.10 A lot of authorities were not aware of this need to have a specific mode of operation implemented in Mode S interrogators to be able to start using SI code in the current traffic environment to detect non-SI code capable transponders. Guidance material have been developed for insertion in Doc 9924.

2.11 The addition of a provision in SARPs will improve the visibility of this required provision and will facilitate the traceability of this requirement during the procurement, testing of systems and the assignment of SI codes by regional offices that will need to ask whether this mode of operation is supported before assigning an SI code to a radar.

> 2.1.9.2 II/SI code operation
>
> Note.- *A mode of operation, known as II/SI code operation, enables the use of SI codes by Mode S ground stations before all transponders are SI code capable in a mixed environment where II and SI codes are used. A radar supporting 2.1.9.2.1 and 2.1.9.2.2 is known as supporting II/SI code operation. More information about this specific II/SI code operation can be found in Doc 9924 Appendix H and J.*
>
> 2.1.9.2.1 Mode S ground station using an SI code shall:
> a) acquire Mode S II-only transponders on the matching II code,
> b) selectively interrogate Mode S II-only transponders on the matching II code
> c) only lockout Mode S II/SI capable transponders.
>
> *Note 1.- A matching II code is an II code whose binary format in the IC field is the same as the binary format in the IC field of the SI code. Each Mode S SI code has one "matching" II code. A table of matching II-SI codes can be found in Doc 9924 Appendix H.*
>
> *Note 2.- Mode S II/SI capable transponders support both II and SI codes as defined in Annex 10 Volume IV. Only locking out Mode S II/SI capable transponders means the legacy Mode S II-only transponders remain are not in a lockout condition and can be acquired by other Mode S ground stations using the matching II code.*
>
> *Note 3.-This requirement is necessary to make possible the allocation of SI codes to Mode S ground stations in areas in which not all transponders are SI capable.*
>
> 2.1.9.2.2 **Recommendation.**— *Mode S II/SI capable interrogator using an II code should be configurable to only lockout Mode S II/SI capable transponders.*
>
> *Note 1.-This mode of operation is used when matching SI codes are used by overlapping interrogators.*

Note 2.- A matching SI code is an SI code whose binary format in the IC field is the same as the binary format in the IC field of the II code. Each Mode S II code has four "matching" SI codes. A table of matching II-SI codes can be found in Doc 9924 Appendix H.

Note 3.- This recommendation is to make possible the allocation of matching II codes to Mode S interrogators in areas in which not all transponders are SI capable and where a matching SI code is allocated.

Note 4.- This recommendation is not necessary if a monitoring programme has demonstrated that all transponders are SI code capable or if SI codes do not need to be used in the ICAO Region. More information on the use of this capability to make possible the allocation of SI codes can be found in Doc 9924 Appendix J.

Acknowledgements

2.12 The author acknowledges the efforts of the members of the Surveillance Panel for the materials in this paper.

3 ACTION BY THE MEETING

3.1 The meeting is invited to note the contents in this paper.

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SP5-WP02.1R4
29/09/23
Appendix A

APPENDIX A

PROPOSAL FOR AMENDMENT (PFA) TO ANNEX10 — *Aeronautical Telecommunications*, Volume IV — *Surveillance and Collision Avoidance Systems*, CONCERNING technical provisions on

1. Updates of technical provisions related to SSR Mode S transponder and 1090 MHz extended squitter automatic dependent surveillance – broadcast (ADS-B) and traffic information services

2. Introduction of ACAS III technical provisions

3. Updates of technical provisions related to airborne surveillance applications

PROPOSED AMENDMENT TO

ANNEX 10

AERONAUTICAL TELECOMMUNICATIONS

VOLUME IV –

SURVEILLANCE AND COLLISION AVOIDANCE SYSTEMS

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

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:

a)	~~Text to be deleted is shown with a line through it~~.	text to be deleted
b)	New text to be inserted is highlighted with grey shading.	new text to be inserted
c)	~~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 Surveillance Panel (SP).

INITIAL PROPOSAL 1

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…

Matching SI code. SI code whose binary format in the IC field is the same as the binary format in the IC field of the II code.

Matching II code. II code whose binary format in the IC field is the same as the binary format in the IC field of the SI code

…

CHAPTER 2. GENERAL

2.1 SECONDARY SURVEILLANCE RADAR (SSR) FUNCTIONAL REQUIREMENTS

2.1.1 General requirement

2.1.1.1 When SSR is installed and maintained in operation as an aid to air traffic services, it shall conform with the provisions of 3.1 unless otherwise specified in this 2.1.

Note.— As referred to in this Annex, Mode A/C transponders are those which conform to the characteristics prescribed in 3.1.1. Mode S transponders are those which conform to the characteristics prescribed in 3.1.1. and 3.1.2. The functional capabilities of Mode A/C transponders are an integral part of ~~those of~~ Mode S transponders.

…

2.1.2 Interrogation modes (ground-to-air)

2.1.2.1 Interrogation for air traffic services shall be performed on the modes described in 3.1.1.4.3 or 3.1.2. The uses of each mode shall be as follows:

1) *Mode A* — to elicit transponder replies for identity and surveillance.

2) *Mode C* — to elicit transponder replies for automatic pressure-altitude transmission and surveillance.

3) *Intermode* —

a) ~~*Mode A/C/S all-call:* to elicit replies for surveillance of Mode A/C transponders and for the acquisition of Mode S transponders.~~

~~b)~~ *Mode A/C-only all-call:* to elicit replies for surveillance of Mode A/C transponders. Mode S transponders do not reply.

Note.— An intermode interrogation using three pulse: P1, P3 and a long P4 and known as Mode A/C/S all-call was initially defined to facilitate the transition from Mode A/C to Mode S. These interrogations are no longer supported by transponders (see 2.1.5.4 7) and therefore cannot be used to support air traffic services.

Origin:	**Rationale:**
SP/5	The amendment (2.1.2.1) is related to removal of the capability from a Mode S transponder to reply to Mode A/C/S all-call interrogations (i.e. Long P4), while keeping minimum SARPs information to cover old legacy transponders.

…

2.1.2.2 Mode A and Mode C interrogations shall be provided. Interrogators commissioned on or after 1 January 2027 shall comply with the Mode A and C requirements specified in 3.1.1

Note.— This requirement may be satisfied by intermode interrogations which elicit Mode A and Mode C replies from Mode A/C transponders.

Origin:	**Rationale:**
SP/5	Rather than set dates for individual Mode A and C interrogator requirements, the TSG decided that the best, and simplest, course of action was to set one date for which all the interrogator requirements in 3.1.1 will apply.

…

2.1.2.4 SIDE-LOBE SUPPRESSION CONTROL INTERROGATION

2.1.2.4.1 Side-lobe suppression shall be provided in accordance with the provisions of 3.1.1.4 and 3.1.1.5 on all Mode A~~,~~ and Mode C ~~and intermode~~ interrogations.

2.1.2.4.2 Side-lobe suppression shall be provided in accordance with the provisions of 3.1.2.1.5.1.2 on all Mode A/C-only all-call interrogations.

2.1.2.4.3~~2~~ Side-lobe suppression shall be provided in accordance with the provisions of 3.1.2.1.5.2.1 on all Mode S-only all-call interrogations.

Origin:	**Rationale:**
SP/5	Added the new section that covers diversity requirements for Mode A and C. Need to check rational here, which should be extracted from ASWG TSG WP 17-07.0R2

2.1.4 Mode A reply codes (information pulses)

…

2.1.4.2 The following Mode A codes shall be reserved for special purposes:

2.1.4.2.1 Code 7700 to provide recognition of an aircraft in an emergency.

2.1.4.2.2 Code 7600 to provide recognition of an aircraft with radiocommunication failure.

2.1.4.2.3 Code 7500 to provide recognition of an aircraft which is being subjected to unlawful interference.

2.1.4.2.4 Code 7400 to provide recognition of an aircraft in a lost C2 link state.

Note.— Refer to Annex 10 Volume VI for the definition of Lost C2 Link state.

2.1.4.3 Appropriate provisions shall be made in ground decoding equipment to ensure immediate recognition of Mode A codes 7400, 7500, 7600 and 7700.

Origin:	**Rationale:**
SP/5	These amendments (2.1.4.2.4 and 2.1.4.3) are related to a special Mode A code indicating lost C2 link state.The integration of RPAS into non-segregated airspace poses several challenges, among which is lost command and control (C2) Link procedures. During a lost C2 Link event, the remotely piloted aircraft (RPA) is flying in a state where it is not under the command of the remote pilot. Accordingly, it is necessary to define mitigations allowing for all stakeholders, whether air traffic control (ATC), or other airspace users, to be made aware in a timely manner of this degraded state. An additions of a special Mode A code to indicate that an RPA is operating without a functional C2 Link between the RPA and the RPS is proposed.

…

2.1.5 Mode S airborne equipment capability

2.1.5.1 Transponder levels. All Mode S transponders shall conform to one of the following five levels:

Note.— The transponder used for a Mode S site monitor may differ from the requirements defined for a normal Mode S transponder. For example, it may be necessary to reply to all-call interrogations when ~~on the ground~~ the effective air/ground state is "on-the-ground". For more details see the Aeronautical Surveillance Manual *(Doc 9924) Appendix D.*

2.1.5.1.1 Level 1 — Level 1 transponders shall have the capabilities prescribed for:

a) Mode A identity and Mode C pressure-altitude reporting (3.1.1);

b) intermode and Mode S all-call transactions (3.1.2.5);

c) addressed surveillance altitude and identity transaction (3.1.2.6.1, 3.1.2.6.3, 3.1.2.6.5 and 3.1.2.6.7);

d) lockout protocols (3.1.2.6.9);

e) basic data protocols except both data link capability reporting (3.1.2.6.10.2.2) and basic dataflash protocol (3.1.2.6.10.3); ~~and~~

f) air-air service and squitter transactions (3.1.2.8)~~.~~; and

g) essential system characteristics of the SSR Mode S Transponder (3.1.2.10) as applicable to the transponder Level.

Note 1.— 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 due to Mode S selective aircraft interrogation.

Note 2.— Level 1 transponders are not sufficient to support ADS-B, elementary surveillance and enhanced surveillance. Also RTCA DO-181F and EUROCAE ED-73F transponder MOPS no longer support the Level 1 transponder.

2.1.5.1.2 *Level 2 transponders*

Note 1— Level 2 transponders may optionally support Comm-A and/or Air Initiated Comm-B. Basic dataflash protocol is another option for the Level 2 transponder.

Note 2— Legacy Level 2 transponders included both Comm-A and Air Initiated Comm-B capabilities.

2.1.5.1.2.1 Level 2 — Level 2 transponders shall have the capabilities of 2.1.5.1.1 and also those prescribed for:

a) standard length communications (Comm-A and Comm-B) (~~3.1.2.6.2, 3.1.2.6.4,~~ 3.1.2.6.6, 3.1.2.6.8, 3.1.2.6.11.2 and~~3.1.2.6.11~~3.1.2.6.11.4);

b) data link capability reporting (3.1.2.6.10.2.2);

c) aircraft identification reporting (3.1.2.9); and

d) ~~data parity with overlay control (3.1.2.6.11.2.5) for equipment certified on or after 1 January 2020~~.SI code capability and 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).

Note 1. — As a minimum, Level 2 Transponders support generation of long replies that enable interrogators to extract data registers from the aircraft.

Note 2.— Level 2 permits aircraft identification reporting and other airborne parameters downlinking using GICB and Comm-B broadcast protocols ~~standard length data link communications from ground to air and air to ground~~.

Note 3. — The aircraft identification reporting capability requires an interface and appropriate input device.

2.1.5.1.2.2 *Level 2 with Comm-A capability*. A level 2 transponders with Comm-A capability shall have the capabilities of 2.1.5.1.2.1 and those prescribed for Comm-A standard length communication described in 3.1.2.6.2, 3.1.2.6.4, and 3.1.2.6.11.1.

Note —Comm-A capability is an optional capability that is not reported to the ground system. The verification of airborne application is necessary to understand whether an aircraft is able to receive and use information received from Comm –A. The existence of a reply to a Comm-A interrogation (UF=20 and 21) is not sufficient to know whether the content of a Comm-A has been passed to an airborne application.

2.1.5.1.2.3 *Level 2 with Air-initiated Comm-B capability.* Level 2 transponders with Air-initiated Comm-B capability shall have the capabilities of 2.1.5.1.2.1 and also those prescribed for Air-initiated Comm-B standard length communication described in 3.1.2.6.11.4.3.

Note 1.— Air-initiated Comm-B capability is an optional capability that is not reported to the ground . However, it will be detectable by the existence of applications supporting communication through Air-initiated Comm-B.

2.1.5.1.2.4 *Level 2 with basic dataflash capability* - Level 2 transponders with basic dataflash capability shall have the capabilities of 2.1.5.1.2.1 and also those prescribed for basic dataflash described in 3.1.2.6.10.3.

2.1.5.1.3 Level 3 — Level 3 transponders shall have the capabilities of 2.1.5.1.2.1, 2.1.5.1.2.2, 2.1.5.1.2.3 and also those prescribed for ground-to-air extended length message (ELM) communications (3.1.2.7.1 to 3.1.2.7.5).

Note 1.— Level 3 transponders include the capabilities of the level 2 transponder with Comm-A and Air-Initiated Comm-B capabilities.

Note 2.— 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.

…

2.1.5.1.6 *Extended squitter* — Extended squitter transponders shall have the capabilities of 2.1.5.1.2.1, 2.1.5.1.2.2, 2.1.5.1.2.3, 2.1.5.1.2.4, 2.1.5.1.3, 2.1.5.1.4 or 2.1.5.1.5, the capabilities prescribed for extended squitter operation (3.1.2.8.6) and the capabilities prescribed for ACAS cross-link operation (3.1.2.8.3 and 3.1.2.8.4). Transponders with these capabilities shall be designated with a suffix "e".

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

~~2.1.5.1.7 *SI capability* — Transponders with the ability to process SI codes shall have the capabilities of 2.1.5.1.1, 2.1.5.1.2.1, 2.1.5.1.2.2, 2.1.5.1.2.3, 2.1.5.1.2.4, 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~~7 *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, except for transmit power levels for the identified equipment class as specified in 5.1.1.

2.1.5.2 Mode S transponder minimum capability

2.1.5.2.1 All Mode S transponders used by international civil air traffic shall conform, at least, to the requirements of Level 2 prescribed in 2.1.5.1.2.1.

Note.— The data parity with overlay control (3.1.2.6.11.2.5) is only available on transponder certified after January 2020 (refer to 2.1.5.4.6).

2.1.5.2.3 **Recommendation.—** *Level 1 Transponders should not be used in area where surveillance interrogator codes are used.*

Note 1.— Level 1 may be admitted for use within an individual State or within the terms of a regional air navigation agreement. The Mode S Level 1 transponder comprises the minimum set of features for compatible operation of Mode S *transponders with SSR Mode S interrogators. It is defined to prevent a proliferation of transponder types below Level 2 which would be incompatible with SSR Mode S interrogators.*

Note 2.— The intent of the requirement for a Level 2 capability is to ensure the widespread use of an ICAO standard transponder capability to allow worldwide planning of Mode S ground facilities and services. The requirement also discourages an initial installation with Level 1 transponders that would be rendered obsolete by later requirements in certain airspace for mandatory carriage of transponders having Level 2 capabilities.

Note 3.— Level 1 transponders does not report surveillance interrogator code capability. They remain unlocked in areas where surveillance interrogator codes are used; therefore, they affect the usage of 1 090 MHz frequency and contribute the 1 090 MHz RF pollution.

2.1.5.2.4. All Mode S Transponders shall maintain the alert condition if the Mode A identity code is changed to one of the Mode A codes of set 1 defined in 3.1.2.6.10.1.1.1.1.

Origin:	**Rationale:**
SP/5	These amendments (through from 2.1.5 to Note 3 of 2.1.5.2.3) are relating to provisions on New Level 2 Transponder, the basic dataflash option and Level 1 transponder. It was identified that various data-link protocols such as Comm-A and Air-Initiated Comm B (AICB) protocols are not used today in the Mode S environment and are not expected to be needed in the foreseeable future. As a result, it is proposed to define requirements for a basic level 2 transponder without Comm-A and AICB (as New Level 2 Transponder) that will become the basis for minimum international Mode S transponder carriage. In order to reduce the usage of the 1 090 MHz frequency, a simple basic protocol known as the basic dataflash protocol, is proposed to be added to announce the changes of some transponder registers that are not changing very often. With the development of services such as the extended squitters for ADS-B and the use of registers to support elementary surveillance and enhanced surveillance, all transponders need to manage transponder registers and associated protocols. These capabilities are not supported in a level 1 transponder. Considering such improved capabilities and advancement of technology, level 1 transponders are no longer expected to be developed. Therefore deletions of obsolete provisions relating to Level 1 transponder are also proposed. Requirements associated to a date have been removed from the basic requirement section to be regrouped in a dedicated section to facilitate their traceability and management by States

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 463 km/h (250 kt) shall operate with antenna diversity as prescribed in 3.1.1.7.18 and 3.1.2.10.4 if:

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

…

Origin:	**Rationale:**
SP/5	Added the new section that covers diversity requirements for Mode A and C.

…

2.1.5.4 TRANSPONDER CAPABILITY REQUIRED AT SPECIFIC DATES ~~CAPABILITY REPORTING IN MODE S SQUITTERS~~

Note.— The capabilities defined in this section allow a smooth implementation of new features and improvements of SSR Mode S transponders. The requirements on transponders are ensured through the certification process used by the State of approval.

Requirements on installation are ensured by the State in charge of the aircraft installation approval. A change applicable to all installations is listed in 2.1.5.2.

~~2.1.5.4.1 Capability reporting in Mode S acquisition squitters (unsolicited downlink transmissions) shall be provided in accordance with the provisions of 3.1.2.8.5.1 for all Mode S transponders installed on or after 1 January 1995.~~

~~2.1.5.4.2 **Recommendation.**— *Transponders equipped for extended squitter operation should have a means to disable acquisition squitters when extended squitters are being emitted.*~~

~~*Note.— This will facilitate the suppression of acquisition squitters if all ACAS units have been converted to receive the extended squitter.*~~

~~2.1.5.5 EXTENDED LENGTH MESSAGE (ELM) TRANSMIT POWER~~

~~In order to facilitate the conversion of existing Mode S transponders to include full Mode S capability, transponders originally manufactured before 1 January 1999 shall be permitted to transmit a burst of 16 ELM segments at a minimum power level of 20 dBW.~~

2.1.5.4.1 All Mode S transponders certified on or after 1 January 1999 shall recover sensitivity to within 3 dB of MTL no later than 45 microseconds after receipt of the sync phase reversal following a Mode S interrogation that is not accepted (3.1.2.4.1.2) or that is accepted but requires no reply.

2.1.5.4.2 Transponder designs first certified on or after 1 January 2011, shall have the spurious Mode A/C reply protection capability as specified in 3.1.2.10.1.1.5.2

2.1.5.4.3 Mode S level 2 transponder certified on or after 1st January 2020 shall have data parity with overlay control as specified in 3.1.2.6.11.2.5.

2.1.5.4.4 Mode S transponder certified on or after 1st January 2020 shall not reply to Mode A/C/S intermode interrogations defined in 3.1.2.1.5.1.1.

Note 1 .— If a transponder receives a Mode A/C/S all-call interrogation, it will be recognized as a Mode A/C-only all-call interrogation.

Note 2 .— A Mode A/C/S all-call interrogation may be accepted by transponder certified before 1st January 2020.

Note 3 .——The replies to Mode A/C/S all-call interrogations are no longer supported by equipment certified on or after 1 January 2020 in order to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.

2.1.5.4.5 Mode S Transponders certified on or after 1st January 2027 shall not accept the TCS, RCS, or SAS commands that may be received when DI=2 .

Note .— TCS,RCS and SAS were previously defined in 3.1.2.6.1.4.1, DI=2.

2.1.5.4.6 Mode S Transponders certified on or after 1st January 2027 shall maintain the alert condition if the Mode A identity code is changed to one of the Mode A codes of set 2 defined in 3.12.6.10.1.1.1.2. 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 defined in set 2 of Mode A codes.

Note.— This allows the report of a C2 link loss for remote piloted aircraft system.

2.1.5.4.7 Mode S Transponders certified on or after 1st January 2027 shall not set to zero in bit 33 of the data link capability report when Aircraft Identification cannot be updated within 8 seconds (see 3.1.2.6.10.2.2.3).

Note.— Transponder certified before 1st January 2027 *may set to zero in bit 33 of the data link capability report when losing the aircraft identification input.*

2.1.5.4.8 Mode S Transponders certified on or after 1st January 2027 shall not set to zero for the aircraft identification upon the loss of the interface providing Aircraft Identification (see 3.1.2.9.1.4).

2.1.5.4.9 Transponders certified on or after 1 January 2027 shall have their RF output power as specified in 3.1.1.7.17.2 and 3.1.2.10.2.1.2,

2.1.5.4.10 **Recommendation.—** *Transmitters used to replace defective obsolete transmitters in transponders should meet the requirement defined in 3.1.7.17.2 and 3.1.2.10.2.1.2.1.*

2.1.5.4.11 Transponders certified on or after 1st January 2027 shall have an improved dead time as specified in 3.1.1.7.3.2 and 3.1.2.10.3.2.2.

2.1.5.4.12 Mode S transponders certified on or after 1st January 2027 shall have a Mode S reply rate limiting of type 1 as specified in 3.1.2.10.3.6.1.2.

2.1.5.4.13 All Mode S transponders certified on or after 1 January 2027 shall conform, at least, to the requirements of Level 2 prescribed in 2.1.5.1.2.1.

Origin:	**Rationale:**
SP/5	Transponder requirements from 2.1.5.4.1 to 2.1.5.4.6, which are existing provisions, are proposed to be regrouped in 2.1.5.4 with some text improvements. This will clean the protocol section and will help States easily identify requirements they have to work on without entering in a detailed review of the protocol. The Mode S interrogation commands affecting airborne/surface format selection and transmission control (rate control subfield (RCS), type control subfield (TCS) and surface antenna subfield (SAS)) were considered undesirable controls of extended squitter and transponder operation. Therefore removal of the rate control subfield (RCS), type control subfield (TCS), and surface antenna subfield (SAS) are proposed in the provision of 2.1.5.4.7. The additional requirement in 2.1.5.4.8 is related to a special Mode A code indicating lost C2 link state. The provision in 2.1.5.4.9 is related to Data Link Capability register changes. The provision in 2.1.5.4.10 is proposed to reflect a change in handling of Aircraft Identification data to not zero-out Aircraft ID in the transponder if the interface providing Aircraft ID is lost. The provisions in 2.1.5.4.11 and 2.1.5.4.12 are proposed to ensure an acceptable level of transmissions before, between and after the pulses of a Mode A/C reply, a Mode S reply or an extended squitter in order to ensure the interoperability between transmitters and receivers of messages on the 1090MHz frequency. The additional provision in 2.1.5.4.13 is related to reduction of transponder dead time. It was pointed out that the current requirement related to transponder dead time is based on old technology and current transponders are much more capable than the dead time limit allowed by SARPs. The provision in 2.1.5.4.14 is associated with the SSR Mode S reply rate limiting, which are technical measures, aiming at reducing 1 090 MHz congestion further, especially those are for protecting against complete loss of surveillance in areas where Mode S interrogations are high. The provision in 2.1.5.4.15 is relating to provisions on New Level 2 Transponder.

~~2.1.5.5 EXTENDED LENGTH MESSAGE (ELM) TRANSMIT POWER~~

~~In order to facilitate the conversion of existing Mode S transponders to include full Mode S capability, transponders originally manufactured before 1 January 1999 shall be permitted to transmit a burst of 16 ELM segments at a minimum power level of 20 dBW.~~

~~*Note.— This represents a 1 dB relaxation from the power requirement specified in 3.1.2.10.2.*~~

Origin: SP/5	**Rationale:** Current standards for ACAS II including ACAS-X depend on the acquisition squitter; therefore it is not appropriate to have a recommendation for transponders to provide the capability to disable acquisition squitter. This amendment is proposed to remove such a legacy recommendation.

…

2.1.8 1090 MHz receiver

2.1.8.1 *Decoding of 1090 MHz Messages*

2.1.8.1.1 1090 MHz receivers produced after 1 January 2027 shall decode messages transmitted by transponder compliant with the active state transponder output power specified in 3.1.2.10.2.1.

Note.— See Appendix D of the Aeronautical Surveillance Manual *(Doc 9924) for guidance on 1 090 pulse decoding in presence of a signal transmitted 50dB below the peak pulse power that could still affect high sensitivity receivers when transmitted in close range.*

2.1.8.1.2 **Recommendation.—** *1090 MHz receivers should decode messages transmitted by transponder compliant with the active state transponder output power specified in 3.1.1.7.17.2 and 3.1.2.10.2.1 in their operational range.*

Note.— The minimum operational range of receivers may need to be changed for transponder compliant with the active state transponder output power specified in 3.1.1.7.17.2 and 3.1.2.10.2.1.

Origin: SP/5	**Rationale:** Additions of provisions on 1090 MHz receiver are proposed to ensure an acceptable level of transmissions before, between and after the pulses of a Mode A/C reply, a Mode S reply or an extended squitter in order to ensure the interoperability between transmitters and receivers of messages on the 1 090 MHz frequency. The proposal is based on the requirement introduced in the new transponder MOPS, but also took into account the previous discussions held at previous TSG and ASWG meetings following an interoperability issue detected in Europe between certain new transponders and existing radars.

2.1.9 Mode S interrogator capability

2.1.9.1 Mode S interrogator shall comply with the requirements defined in 3.1.1 and 3.1.2.

2.1.9.2 Mode S interrogator shall not use Mode A/C/S all-call interrogations.

Note 1.— The use of Mode A/C/S all-call interrogations does not allow the use of stochastic lockout override and therefore might not ensure a good probability of acquisition in areas of high density of flights or when other interrogators lockout transponder on II=0 for supplementary acquisition.

Note 2.— The replies to Mode A/C/S all-call interrogations is no longer supported by equipment certified on or after 1 January 2020 (refer to 2.1.5.4.7) in order to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.

Origin: SP/5	**Rationale:** This section is created to contain top level interrogator requirements. In this manner, States will clearly see which requirements they have to work on without entering in a detailed review of the protocol. The requirement was previously existing in 3.1.2.1.5.1.1.1. The note provides information on the reason and points to the section where the counterpart on the transponder side is described.

2.1.9.3 II/SI code operation

Note .- A mode of operation, known as II/SI code operation, enables the use of SI codes by Mode S ground stations before all transponders are SI code capable in a mixed environment where II and SI codes are used. A radar supporting 2.1.9.3.1 and 2.1.9.3.2 is known as supporting II/SI code operation. More information about this specific II/SI code operation can be found in Doc 9924 Appendix H and J.

2.1.9.3.1 Mode S ground station using an SI code shall:

a) acquire Mode S II-only transponders on the matching II code,

b) selectively interrogate Mode S II-only transponders on the matching II code

c) not lockout Mode S II-only transponders when ground stations with overlapping coverage are assigned matching II or SI codes.

Note 1.- A matching II code is an II code whose binary format in the IC field is the same as the binary format in the IC field of the SI code. Each Mode S SI code has one "matching" II code. A table of matching II-SI codes can be found in Doc 9924 Appendix H.

Note 2.- Mode S II/SI capable transponders support both II and SI codes as defined in Annex 10 Volume IV. Only locking out Mode S II/SI capable transponders means the legacy Mode S II-only transponders are not in a lockout condition and can be acquired by other Mode S ground stations using the matching II code . The suppression of lockout for Mode S II-only transponder is only used when there is overlapping coverage with a ground station using a matching II or SI code, as it is important to use lockout to reduce RF transmissions.

Note 3.-This requirement is necessary to make possible the assignment of SI codes to Mode S ground stations in areas in which not all transponders are SI capable.

2.1.9.3.2 **Recommendation.—** *Mode S II/SI capable interrogator using an II code should be configurable to only lockout Mode S II/SI capable transponders.*

Note 1.-This mode of operation is used when matching SI codes are used by overlapping interrogators.

Note 2.- A matching SI code is an SI code whose binary format in the IC field is the same as the binary format in the IC field of the II code. Each Mode S II code has four "matching" SI codes. A table of matching II-SI codes can be found in Doc 9924 Appendix H.

Note 3.- This recommendation is to make possible the assignment of matching II codes to Mode S interrogators in areas in which not all transponders are SI capable and where a matching SI code is assigned.

Note 4.- This recommendation is not necessary if a monitoring programme has demonstrated that all transponders are SI code capable or if SI codes do not need to be used in the ICAO Region. More information on the use of this capability to make possible the assignment of SI codes can be found in Doc 9924 Appendix J.

Origin: SP/5	**Rationale:** Due to the lack of II codes, radars must use an SI code in an environment of SI and II-only code capable aircraft. A few Non-SI code capable transponders will remain for a long time. It is therefore required to use a specific mode of operation to use SI codes. The proposed amendment contains a change to add this specific mode of operation to radars that are SI capable..

2.2 HUMAN FACTORS CONSIDERATIONS

Recommendation.— *Human Factors principles should be observed in the design and certification of surveillance radar, transponder and collision avoidance systems.*

Note.— Guidance material on Human Factors principles can be found in Doc 9683, Human Factors Training Manual *and Circular 249* (Human Factors Digest No. 11 — Human Factors in CNS/ATM Systems).

…

2.2.1.3 Recommendation.— The flight crew should have access at all times to the information of the operational state of the transponder.

Note.— Information on the monitoring of the operational state of the transponder is provided in RTCA DO-181 F~~E~~, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/ Mode Select (ATCRBS/Mode S) Airborne Equipment, *and in* EUROCAE ED-73F~~E~~, Minimum Operational Performance ~~Specification~~ Standards (MOPS) for Secondary Surveillance Radar Mode S Transponders.

…

2.3 Interference Tolerance Criterion

2.3.1 Aeronautical surveillance and collision avoidance system receivers defined in this volume utilizing the 1030 and/or 1090 megahertz channels shall be able to meet their performance requirements under an average interference power to average noise power level ratio of no more than minus 10 decibels.

Note1. — Interference levels above this level may be harmful to the intended operation of the systems in this volume. This would apply to the combination of all non-pulsed interference sources present. Pulsed interference sources or sources with less than 100 percent operational duty cycle need to be evaluated on a case-by-case basis.

Note2. — Additional information on application of this interference tolerance criterion can be found in ICAO Doc. 9924, including the description of interference.

Note3. — Compatibility between ICAO standardized systems may be evaluated on a case-by-case basis, and interference mitigations may be used which are only available to ICAO-standardized systems.

Note4.— - The interference should be treated as additive noise such that interference 10 dB below a receiver's baseline noise floor generates 0.4 dB of additive noise.

Origin	Rationale
SP/5	There are new systems seeking to operate in spectrum closer to the 1030/1090 MHz frequencies. In order to understand what levels of harmful interference would degrade the performance of 1030/1090 MHz surveillance and collision avoidance systems standardized by this volume, interference tolerance criterion is necessary to define the level of interference SP receivers should expect to tolerate. Additionally, developers of new systems will have clear criterion on which to base studies to protect SP systems. This addition to the SARPs is necessary to define the level of interference tolerance for the SP receivers standardized by Annex 10 Volume IV.

…

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. Chapter 5 prescribes additional requirements on Mode S extended squitters.

…

3.1.1 ~~Systems having only~~ Mode A and Mode C capabilities

…

3.1.1.2.2 The frequency tolerance shall be plus or minus ~~3~~1 MHz.

Origin:	**Rationale:**
SP/5	The rational included in ASWG TSG WP 17-07.0R2 (Adopts the value used in DO-181F/ED-73F) does not work. May be we can say: The value was updated based on the expert groups extensive review on A10V4 as well as relevant SMO's specifications? .

...

3.1.1.4 INTERROGATION MODES (SIGNALS-IN-SPACE)

Note — The paragraphs herein describe the signals-in-space at the antenna(s) of the interrogator. Table 3-11 provides a summary of the interrogation signal details.

Origin:	**Rationale:**
SP/5	No current guidance as to where these signals are specified. Added a reference to Table 3-11, which is now a summary of all the signal in space requirements for each interrogation mode. (ASWG TSG WP 17-07.0R2)

…

3.1.1.4.3 The interval between P_1 and P_3 shall determine the mode of interrogation and shall be as follows:

Mode A 8 ±0.~~2~~18 microseconds
Mode C 21 ±0.~~2~~18 microseconds

3.1.1.4.4 The interval between P_1 and P_2 shall be 2.0 plus or minus 0.1~~5~~ microseconds.

3.1.1.4.5 The duration of pulses P_1, P_2 and P_3 shall be 0.8 plus or minus 0.~~1~~09 microsecond.

Origin:	**Rationale:**
SP/5	Changed to align with the values at the interrogator in the current Table 3-11. (ASWG TSG WP 17-07.0R2)

…

3.1.1.5 INTERROGATOR AND CONTROL TRANSMISSION CHARACTERISTICS (INTERROGATION SIDE-LOBE SUPPRESSION — SIGNALS-IN-SPACE)

3.1.1.5.1 The radiated amplitude of P2 ~~at the antenna of the transponder~~ shall be:

a) equal to or greater than the radiated amplitude of P1 from the side-lobe transmissions of the antenna radiating P1; and

b) at a level lower than 9 dB below the radiated amplitude of P1, within the desired arc of interrogation.

3.1.1.5.2 Within the desired beam width of the directional interrogation (main lobe), the radiated amplitude of P3 shall be within 0.5~~1~~ dB of the radiated amplitude of P1.

Origin:	**Rationale**:
SP/5	Changed to align with the values at the interrogator in the current Table 3-11. (ASWG TSG WP 17-07.0R2)

3.1.1.5.3 One or two control pulses (P_2 alone, or P_1 and P_2) shall be transmitted using a separate antenna pattern to suppress responses from aircraft in the side lobes of the interrogator antenna.

Note 1 – The use of control P_1 and P_2 is further described in Doc 9924.

Note 2 - When using control P_1 and P_2, separate RF paths are used for the interrogation P_1 and the control P_1. The pulse characteristics and timing described in chapter 3.1.1.4 apply to both P_1 pulses.

Origin:	**Rationale:**
SP/5	(ASWG TSG WP 17-07.0R2) Rational from the above WP (Added to better cover I2SLS operation per a request from Anne Demers) does not work. Need to check it the original WP. And most probably we need to refine the note above if not the deletion.

…

3.1.1.6 REPLY TRANSMISSION CHARACTERISTICS (SIGNALS-IN-SPACE)

Note — The paragraphs herein describe the signals-in-space as at the antenna(s) of the transponder.

…

3.1.1.7 TECHNICAL CHARACTERISTICS OF TRANSPONDERS WITH MODE A AND MODE C CAPABILITIES ONLY

3.1.1.7.1 Reply. The transponder shall reply (not less than 90 per cent triggering) when all of the following conditions have been met:

a) the received amplitude of P3 is ~~in excess of a level~~ within plus or minus 1 dB ~~below the received amplitude of P1 but no greater than 3 dB above~~ of the received amplitude of P1;

b) either no pulse is received in the interval 1.3 microseconds to 2.7 microseconds after P1, or P1 exceeds by more than 9 dB any pulse received in this interval;

c) the received amplitude of a proper interrogation is more than 10 dB above the received amplitude of random pulses where the latter are not recognized by the transponder as P1, P2 or P3.

d) the interval between P1 and P3 is 8 plus or minus 0.2 microseconds (Mode A), or 21 plus or minus 0.2 microseconds (Mode C)

e) the duration of P1 and P3 is 0.8 plus or minus 0.1 microseconds.

Origin: SP/5	**Rationale:** (ASWG TSG WP 17-07.0R2) DO-181F only requires up to +1 dB. Suggest changing so that the SARPS is not more strict than the MOPS. (Note that ED-73F does not appear to cover this condition at all). Currently, the "must accept" type requirements seem to be implied by the specification of the interrogation signal. Since we are tightening the interrogation signals, this needs to be added to allow tolerance between the interrogator and transponder (and to align with the MOPS). Note also that this section is not currently referred to by the Mode S section of the SARPS, making is ambiguous how Mode S transponders are supposed to reply to ATCRBS signals.

…

3.1.1.7.3 Dead time. ~~After recognition of a proper interrogation, the transponder shall not reply to any other interrogation, at least for the duration of the reply pulse train. This dead time shall end no later than 125 microseconds after the transmission of the last reply pulse of the group.~~

3.1.1.7.3.1 For all transponders, the time interval beginning at the end of a reply transmission and ending when the receiver has regained sensitivity to within 3 dB of MTL (dead time) shall not exceed 125 microseconds.

3.1.1.7.3.2 For transponders with improved dead time, the time interval beginning at the end of a reply transmission and ending when the receiver has regained sensitivity to within 3 dB of MTL (dead time) shall not exceed 20 microseconds.

Origin: SP/5	**Rationale**: (ASWG TSG WP 17-07.0R2) Aligned with the dead time changes previously made to Mode S. Need to refine this rational.

…

3.1.1.7.5 *RECEIVER SENSITIVITY AND DYNAMIC RANGE*

3.1.1.7.5.1 The minimum triggering level of the transponder shall be such that replies are generated to at least 90 per cent of the interrogation signals when:

a) the two pulses P_1 and P_3 constituting an interrogation are of equal amplitude and P_2 is not detected; and

b) the amplitude of these signals is nominally ~~71~~73 dB below 1 mW, with limits between 69 dB and 77 dB below 1 mW.

Origin: SP/5	**Rationale:** (ASWG TSG WP 17-07.0R2) This aligns the nominal MTL with DO-181F/ED-73F.

…

3.1.1.7.6 Pulse duration discrimination. Signals of received amplitude between minimum triggering level and ~~6 dB~~ -45 dBm~~above this level~~, and consisting of P_1 and/or P_3 with ~~of~~ a duration less than 0.3 microsecond, shall not cause the transponder to initiate reply or suppression action more than 10 per cent of the time. With the exception of single pulses with amplitude variations approximating an interrogation, any single pulse of a duration more than 1.5 microseconds shall not cause the transponder to initiate reply or suppression action more than 10 per cent of the time over the signal amplitude range of minimum triggering level (MTL) to 50 dB above that level.

Origin:	**Rationale:**
SP/5	(ASWG TSG WP 17-07.0R2) The first sentence is modified to align the requirement with DO-144A and DO-181F/ED-73F. The 10 per cent criteria is added to the second sentence to align with the first (note the second sentence has no corresponding DO-181F/ED-73F requirement).

…

3.1.1.7.8 *SPURIOUS EMISSIONS AND SPURIOUS RESPONSES*

3.1.1.7.8.1 *Equipment random triggering rate.* In the absence of valid interrogation signals, transponders shall not generate more than 5 unwanted Mode A or Mode C replies per second as integrated over an interval of at least 30 seconds.

3.1.1.7.8.2 Installed r~~R~~andom triggering rate. In the absence of valid interrogation signals, ~~Mode A/C~~ transponders shall not generate more than 30 unwanted Mode A or Mode C replies per second as integrated over an interval of ~~equivalent to~~ at least ~~300 random triggers, or~~ 30 seconds~~, whichever is less~~. This random triggering rate shall not be exceeded when all possible interfering equipments installed in the same aircraft are operating at maximum interference levels.

3.1.1.7.8.~~1~~3 Random triggering rate in the presence of low-level in-band continuous wave (CW) interference. The total random trigger rate on all Mode A and/or Mode C replies 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 1 030 ±0.2 MHz and a signal level of –60 dBm or less.

Origin:	**Rationale:**
SP/5	(ASWG TSG WP 17-07.0R2) The requirement from DO-181F/ED-73F that applies at the equipment level is added. The existing SARPS requirement is maintained with the addition of "installed" in the title. Additionally, the allowance to average over 300 random triggers is removed as that seems too low of a level of detail.

3.1.1.7.8.4 *SPURIOUS RADIATION*

Recommendation.— *CW radiation should not exceed 70 dB below 1 W for the transponder.*

3.1.1.7.8.5 *SPURIOUS RESPONSES*

3.1.1.7.8.5.1 **Recommendation.**— *The response to signals not within the receiver pass band should be at least 60 dB below normal sensitivity*.

Origin:	**Rationale:**
SP/5	The approach is to keep all requirements on technical characteristics of transponders in only one section, section 3.1.1.7 which is already defined to contain such requirements. Therefore existing 3.1.1.11 (spurious emissions and spurious responses), which contains specific technical characteristics of transponders with Mode A and Mode C capabilities is moved as a new section of 3.1.1.7.

…

3.1.1.7.8.5.2 For transponders with spurious Mode A/C reply protection capability, the spurious Mode A/C reply ratio resulting from low level Mode S interrogations shall be no more than:

a) an average of 1 per cent in the input interrogation signal range between –81 dBm and the Mode S MTL; and

b) a maximum of 3 per cent at any given level in the input interrogation signal range between –81 dBm and the Mode S MTL.

Note 1.— Failure to detect a low level Mode S interrogation can also result in the transponder decoding a three-pulse Mode A/C/S all-call interrogation. This would result in the transponder responding with a Mode S all-call (DF = 11) reply. The above requirement will also control these DF = 11 replies since it places a limit on the probability of failing to correctly detect the Mode S interrogation.

Note 2.— More information about issuing a type certificate for aircraft and separate design approval can be found in the Airworthiness Manual *(Doc 9760).*

Origin: SP/5	**Rationale:** The approach is to keep all requirements on technical characteristics of transponders in only one section, section 3.1.1.7 which is already defined to contain such requirements. Therefore existing 3.1.2.10.1.1.5.2 is moved as a new section of 3.1.1.7.

…

3.1.1.7.9.2 Reply rate limit control. To protect the system from the effects of transponder over-interrogation by preventing response to weaker signals when a predetermined reply rate has been reached, a sensitivity reduction type reply limit control shall be incorporated in the equipment. The ~~range of this control~~ limit shall be set ~~permit adjustment, as a minimum, to any value~~ between 500 and 2 000 Mode A/C replies per second~~, or to the maximum reply rate capability if less than 2 000 replies per second~~, without regard to the number of pulses in each reply. Sensitivity reduction in excess of 3 dB shall not take effect until 90 per cent of the selected value is exceeded. ~~Sensitivity reduction shall be at least 30 dB for rates in excess of 150 per cent of the selected value.~~

3.1.1.7.10 Reply delay and jitter. The time delay between the arrival, at the transponder receiver, of the leading edge of P3 and the transmission of the leading edge of the first pulse of the reply shall be 3 plus or minus 0.5 microseconds. The total jitter of the reply pulse code group, with respect to P3, shall not exceed 0.1 microsecond for receiver input levels between 3 dB and 50 dB above minimum triggering level. Delay variations between Mode A and Mode C~~modes on which the transponder is capable of replying~~ shall not exceed 0.2 microseconds.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 Modified to align with DO-181F/ED-73F Since this paragraph now applies to transponders with more than 2 modes, it is needed to specify which modes are being referred to here.

…

3.1.1.7.12.1.1 The Mode A code shall be ~~manually~~ selected from the 4 096 codes available

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 There is no equivalent MOPS requirement. Depending on the definition of “manually”, not all transponders may comply.

…

3.1.1.7.13 Transmission of the special position identification (SPI) pulse. When required, this pulse shall be transmitted with Mode A replies, as specified in 3.1.1.6.3, for a period of between 18 plus or minus 1 ~~15 and 30~~ second~~s~~

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 Changed to align with DO-181F/ED-73F.

…

3.1.1.7.15 *Simultaneous Signals.* If a $P_1 - P_2$ suppression pair and a Mode A or Mode C interrogation are recognized simultaneously, the transponder shall be suppressed. An interrogation shall not be recognized as Mode A or Mode C if the transponder is in suppression (3.1.1.7.4). If a Mode A and a Mode C interrogation are recognized simultaneously the transponder shall complete the transaction cycle as if only a Mode C interrogation had been recognized.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 As this is a requirement dealing with ATCRBS, it has been moved from 3.1.2.4.1.1.1

3.1.1.7.16 *Reply ratio in the presence of low-level in-band CW interference.* In the presence of non-coherent CW interference at a frequency of 1 030 ±0.2 MHz at signal levels of 20 dB or more below the desired Mode A/C interrogation signal level, the transponder shall reply correctly to at least 90 per cent of the interrogations.

3.1.1.7.17 *Unwanted Output Power*

3.1.1.7.17.1 *Inactive state transponder output power.* When the transponder is in the inactive state the peak power at 1 090 MHz plus or minus 3 MHz at the antenna end of the transmission line of the transponder shall not exceed –50 dBm. The inactive state is defined as the entire period between transmissions, less 10-microsecond transition periods preceding the first pulse and plus 10 microseconds transition period following the last pulse of the transmission. See figure 3-9.

Note 1.— Inactive state transponder power is constrained in this way to ensure that an aircraft, when located as near as 185 m (0.1 NM) to a Mode A/C or Mode S interrogator, does not cause interference to that installation.

Note 2. — Transponders with Mode S capability and installed with an ACAS unit have stricter requirements defined in 3.1.2.10.2.1.1.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 ACAS language that was previously in the requirement was removed and Note 2 was added per ASWG recommendation.

3.1.1.7.17.2 *Active state transponder output power.*

3.1.1.7.17.2.1 The RF output power shall be less than or equal to the peak pulse power minus 50 dB for the interval starting 10 microseconds prior to the Mode A/C transmission and for the interval of 10 microseconds following a Mode A/C transmission.

3.1.1.7.17.2.2 For intervals between transmitted pulses that are greater than 0.5 microseconds, the power level at the lowest point within the interval shall be 50 dB or more below the peak pulse power.

Note 1.- These power limitations protect 1090 MHz receivers from potential missed decodes when signals are received at close range and within desired detection range. In the absence of such limits, signal levels during non-pulse intervals can occur above receiver thresholds and can lead to unintended distortion of pulse positions or false pulse decodes preventing proper detection of transmitted signals. It also makes it more difficult for receivers to decode overlapped replies.

Note 2.- It is possible that a signal transmitted 50dB below the peak pulse power can still affect high sensitivity receivers when transmitted in close range. More information is available in the Aeronautical Surveillance Manual (Doc 9924).

Note 3. – Information on how to verify unwanted output power can be found in RTCA DO-181F and EUROCAE ED-73F.

Note 4.- The presence of signal at a level of 50 dB or more below the peak power may not be measurable within the first 0.5 microseconds following the transmission of a pulse because of the allowed decay time.

Note 5. – Transmitters compliant with RTCA DO-181F and EUROCAE ED-73F meet the requirement defined in 3.1.2.10.2.1.2.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 These requirements are not specific to Mode S and should also apply to ATCRBS transponders. Since there is no section for global requirements, it is suggested they be repeated here with slight modifications to remove Mode S specific wording.

3.1.1.7.18 *Transponder antenna system and diversity operation.* 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.

3.1.1.7.18.1 *Radiation pattern.* The radiation pattern of antennas when installed on an aircraft shall be nominally equivalent to that of a quarter-wave monopole on a ground plane.

Note.— Transponder antennas designed to increase gain at the expense of vertical beamwidth are undesirable because of their poor performance during turns.

3.1.1.7.18.2 *Antenna location.* The top and bottom antennas shall be mounted as near as possible to the centre line of the fuselage. Antennas shall be located so as to minimize obstruction to their fields in the horizontal plane.

3.1.1.7.18.2.1 **Recommendation.—** *The horizontal distance between the top and bottom antennas should not be greater than 7.6 m (25 ft).*

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 3.1.2.10.4.5.

3.1.1.7.18.3 *Antenna selection.* Transponders equipped for diversity operation shall have the capability to evaluate a pulse sequence simultaneously received on both antenna channels to determine individually for each channel if the P_1 pulse and the P_3 pulse of a Mode A or Mode C interrogation meet the requirements for Mode A and Mode C interrogations as defined in 3.1.1.

3.1.1.7.18.3.1 If the two channels simultaneously a $P_1 – P_3$ pulse pair that meets the requirements for a Mode A or Mode C interrogation, the antenna at which the signal strength is greater shall be selected for the transmission of the reply.

3.1.1.7.18.3.2 If only one channel receives a pulse pair that meets the requirements for an interrogation, or if only one channel accepts an interrogation, the antenna associated with that channel shall be selected regardless of received signal strength.

3.1.1.7.18.3.3 *Selection threshold.* If antenna selection is based on signal level, it shall be carried out at all signal levels between MTL and –21 dBm.

Note.— Either antenna may be selected if the difference in signal level is less than 3 dB.

3.1.1.7.18.3.4 *Received signal delay tolerance.* If an interrogation is received at one antenna 0.125 microsecond or less in advance of reception at the other antenna, the interrogations shall be considered to be simultaneous interrogations, and the above antenna selection criteria applied. If an accepted interrogation is received at either antenna 0.375 microsecond or more in advance of reception at the other antenna, the antenna selected for the reply shall be that which received the earlier interrogation. If the relative time of receipt is between 0.125 and 0.375 microsecond, the transponder shall select the antenna for reply either on the basis of the simultaneous interrogation criteria or on the basis of the earlier time of arrival.

3.1.1.7.18.4 *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.

3.1.1.7.18.5 *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 centre line between the two antennas) shall not exceed 0.13 microsecond 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.

Note.— This requirement limits apparent jitter caused by antenna switching and by cable delay differences.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 These requirements are not specific to Mode S and should also apply to ATCRBS transponders with diversity. Since there is no section for global requirements, it is suggested they be repeated here with slight modifications to remove Mode S specific wording.

3.1.1.7.19 *Variable direct data.* Variable direct data are data from the aircraft which can change in flight and shall be:

a) the Mode C altitude code (3.1.1.7.12.2);

b) the Mode A identity code (3.1.1.7.12.1);

c) the SPI condition (3.1.1.6.3).

3.1.1.7.19.1 *Interfaces for variable direct data.*

3.1.1.7.19.1.1 A means shall be provided, while on the ground or during flight, for the SPI condition to be inserted by the pilot, without the entry or modification of other flight data.

3.1.1.7.19.1.2 A means shall be provided, while on the ground or during flight, for the Mode A identity code to be displayed to the pilot and modified without the entry or modification of other flight data.

Note.— Implementation of the pilot action for entry of data will be as simple and efficient as possible in order to minimize the time required and reduce the possibility of errors in the data entry.

3.1.1.7.19.1.3 Interfaces shall be included to accept the pressure-altitude.

Note.— A specific interface design for the variable direct data is not prescribed.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 These requirements are not specific to Mode S and should also apply to ATCRBS transponders. Since there is no section for global requirements, it is suggested they be repeated here with modifications to remove Mode S specific wording.

3.1.1.8 TECHNICAL CHARACTERISTICS OF GROUND INTERROGATORS~~ WITH~~ MODE A AND MODE C CAPABILITIES ~~ONLY~~

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2 This change would make it so that the requirements apply to Mode A/C capabilities regardless of what additional capabilities may exist.

…

3.1.1.8.1 *Interrogation repetition frequency*. The maximum interrogation repetition frequency shall be 450 interrogations per second.

3.1.1.8.1.1 **Recommendation.—** *To minimize unnecessary transponder triggering and the resulting high density of mutual interference, all interrogators should use the lowest practicable interrogator repetition frequency that is consistent with the display characteristics, interrogator antenna beam width and antenna rotation speed employed.*

3.1.1.8.2 RADIATED POWER

Recommendation.— *In order to minimize system interference the effective radiated power of interrogators should be reduced to the lowest value consistent with the operationally required range of each individual interrogator site.*

3.1.1.8.2.1 *Inactive-state interrogator output power*. When the interrogator transmitter is not transmitting an interrogation, its output shall not exceed –5 dBm effective radiated power at any frequency between 960 MHz and 1 215 MHz.

Note.— This constraint ensures that aircraft flying near the interrogator (as close as 1.85 km (1 NM)) will not receive interference that would prevent them from being tracked by another interrogator. In certain instances even smaller interrogator-to-aircraft distances are of significance, for example if Mode S surveillance on the airport surface is used. In such cases a further restraint on inactive state interrogator output power may be necessary.

Origin: SP/5	**Rationale:** ASWG TSG WP 17-07.0R2. Copied over from Mode S.

3.1.1.8.3 **Recommendation.—** *When Mode C information is to be used from aircraft flying below transition levels, the altimeter pressure reference datum should be taken into account.*

Note.— Use of Mode C below transition levels is in accordance with the philosophy that Mode C can usefully be employed in all environments.

3.1.1.~~9~~8.4 INTERROGATOR RADIATED FIELD PATTERN

Recommendation.— *The beam width of the directional interrogator antenna radiating* P_3 *should not be wider than is operationally required. The side- and back-lobe radiation of the directional antenna should be at least 24 dB below the peak of the main-lobe radiation.*

Note .- When the rotating antenna of a ground station is no longer rotating at its specified rate, the RF transmissions need to be inhibited to protect transponder operation as well as the 1090 MHz frequency as aircraft could remain for a long time in the beam of the antenna. More information can be found in Doc 9924 Appendix D and M.

3.1.1.~~10~~8.5 INTERROGATOR MONITOR

3.1.1.~~10~~8.5.1 The range and azimuth accuracy of the ground interrogator shall be monitored at sufficiently frequent intervals to ensure system integrity.

Note.— Interrogators that are associated with and operated in conjunction with primary radar may use the primary radar as the monitoring device; alternatively, an electronic range and azimuth accuracy monitor would be required.

3.1.1.~~10~~8.5.2 **Recommendation.—** *In addition to range and azimuth monitoring, provision should be made to monitor continuously the other critical parameters of the ground interrogator for any degradation of performance exceeding the allowable system tolerances and to provide an indication of any such occurrence.*

3.1.1.8.6 SPURIOUS EMISSIONS AND SPURIOUS RESPONSES

3.1.1.8.6.1 *SPURIOUS RADIATION*

Recommendation.— *CW radiation should not exceed 76 dB below 1 W for the interrogator.*

~~3.1.1.11 SPURIOUS EMISSIONS AND SPURIOUS RESPONSES~~

~~3.1.1.11.1 *SPURIOUS RADIATION*~~

~~**Recommendation.—** *CW radiation should not exceed 76 dB below 1 W for the interrogator and 70 dB below 1 W for the transponder.*~~

~~3.1.1.11.2 *SPURIOUS RESPONSES*~~

~~**Recommendation.—** *The response of both airborne and ground equipment to signals not within the receiver pass band should be at least 60 dB below normal sensitivity.*~~

Origin:	**Rationale:**
SP/5	In order to keep a clear structure of the SARPS, all transponder technical requirement are regrouped in one section, the existing section 3.1.1.7 which is already dedicated to transponder, and all requirements for interrogator in another separate section, the existing section 3.1.1.8 already defined for ground interrogator.

3.1.2 ~~Systems having~~ Mode S and Intermode capabilities

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Change to cover the capability rather than the whole system. Since intermode is generally considered to be a separate capability than Mode S, it has been added to the title.

3.1.2.1 Interrogation signals-in-space characteristics. The paragraphs herein describe the signals-in-space ~~as they can be expected to appear~~ at the antenna(s) of the ~~transponder~~ interrogator.

~~*Note.— Because signals can be corrupted in propagation, certain interrogation pulse duration, pulse spacing and pulse amplitude tolerances are more stringent for interrogators as described in 3.1.2.11.4.*~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Signals should be specified at the system that radiates those signals. It is generally not possible to measure the signals at the transponder. Additionally, signals are routinely corrupted during propagation without any possible means to control those corruptions. This note is no longer needed as all actual interrogator requirements will be covered here.

…

3.1.2.1.4.1 Pulse modulation. Intermode and Mode S interrogations shall consist of a sequence of pulses as specified in 3.1.2.1.5 and Tables 3-1, ~~3-2,~~ 3-3, and 3-4.

Note 1.— The 0.8 microsecond pulses used in intermode and Mode S interrogations are identical in shape to those used in Modes A and C as defined in 3.1.1.4.

Note 2.— Table 3-11 provides a summary of the interrogation signal details.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Table 3-2 gives reply pulse characteristics and should not be applicable to interrogators. Added a reference to Table 3-11 for clarity.

…

3.1.2.1.5 *Pulse and phase reversal sequences.* Specific sequences of the pulses or phase reversals described in 3.1.2.1.4 shall constitute interrogations.

3.1.2.1.5.1 *Intermode interrogation*

3.1.2.1.5.1.1 *Mode A/C/S all-call interrogation.*

Note. 1 — ~~3.1.2.1.5.1.1 *Mode A/C/S all-call interrogation.*~~ *This interrogation is defined as* ~~*shall consist of three pulses:*~~ *P_1, P_3, and the long P_4 as shown in Figure 3-3.*~~One or two control pulses (P_2 alone, or P_1 and P_2) shall be transmitted using a separate antenna pattern to suppress responses from aircraft in the side lobes of the interrogator antenna.~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Removed shall and moved this definition to a note per ASWG.

Note 2.—The replies to Mode A/C/S all-call interrogations are no longer supported by equipment certified on or after 1 January 2020 (2.1.5.4.7) in order to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.~~*The Mode A/C/S all-call interrogation elicits a Mode A or Mode C reply (depending on the* P_1*-*P_3 *pulse spacing) from a Mode A/C transponder because it does not recognize the* P_4 *pulse. A Mode S transponder recognizes the long* P_4 *pulse and responds with a Mode S reply. This interrogation was originally planned for use by isolated or clustered interrogators. Lockout for this interrogation was based on the use of II equals 0. The development of the Mode S subnetwork now dictates the use of a non-zero II code for communication purposes. For this reason, II equals 0 has been reserved for use in support of a form of Mode S acquisition that uses stochastic/lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5). The Mode A/C/S all-call cannot be used with full Mode S operation since II equals 0 can only be locked out for short time periods (3.1.2.5.2.1.5.2.1). This interrogation cannot be used with stochastic/lockout override, since probability of reply cannot be specified.*~~

~~3.1.2.1.5.1.1.1 Mode A/C/S all-call interrogations shall not be used on or after 1 January 2020.~~

~~*Note 1.— The use of Mode A/C/S all-call interrogations does not allow the use of stochastic lockout override and therefore might not ensure a good probability of acquisition in areas of high density of flights or when other interrogators lockout transponder on II=0 for supplementary acquisition.*~~

~~*Note 2.— The replies to Mode A/C/S all-call interrogations will no longer be supported by equipment certified on or after 1 January 2020 in order to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.*~~

3.1.2.1.5.1.2 *Mode A/C-only all-call interrogation.*

Note 1. — ~~3.1.2.1.5.1.2 *Mode A/C-only all-call interrogation.*~~ *This interrogation is defined as* ~~*shall*~~ *P_1, P_3, and a short P_4 as shown in Figure 3-3*~~be identical to that of the Mode A/C/S all-call interrogation except that the short P_4 pulse shall be used.~~

Note 2 .— The Mode A/C-only all-call interrogation elicits a Mode A or Mode C reply from a Mode A/C transponder. A Mode S transponder recognizes the short P_4 *pulse and does not reply to this interrogation.*

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.1.5.1.1 to 3.1.2.1.5.1.2) is related to removal of the capability from a Mode S transponder to reply to Mode A/C/S all-call interrogations (i.e. Long P4), while keeping minimum SARPs information to cover old legacy transponders. Since it was recognized that an important source of Mode S RF pollution on 1090 MHz is the DF=11 all call replies generated in response to wrongly detected inter-mode A/C/S all-call interrogations (long P4), amendment 89 of Annex 10 Volume IV introduced changes to eliminate the reply to Mode A/C/S all-call interrogations. However, such provisions were complicated by the impact that the changes have on detection of the Mode A/C-only all-call interrogation (short P4) and the lack of clarity in detection criteria for this type of interrogation created confusion. This PfA provided clarification on such provisions.

3.1.2.1.5.1.~~3~~2.1 *Pulse intervals.* The pulse interval~~s~~ between P_1, ~~P_2~~ and P_3 shall be as defined in 3.1.1.4.3 ~~and 3.1.1.4.4~~. The pulse interval between P_3 and P_4 shall be 2 plus or minus 0.0~~5~~4 microsecond.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Changed to align with the value at the interrogator in the current Table 3-11. Moved requirement related to P_2 to new 3.1.2.1.5.1.2.3 below. Modified the numbering of this paragraph to make it a subparagraph to the Mode A/C-only all-call.

3.1.2.1.5.1.~~4~~2.2 *Pulse amplitudes.* Relative amplitudes between pulses P_1, ~~P_2~~ and P_3 shall be in accordance with 3.1.1.5. The amplitude of P_4 shall be within -0.5~~1~~/+2.5 dB of the amplitude of P_3.

Note.— Because signals can be corrupted in propagation, certain interrogation pulse duration, pulse spacing and pulse amplitude tolerances are more stringent for interrogators as described in 3.1.2.11.4.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Changed to align with the value at the interrogator in the current Table 3-11 ASWG TSG WP 17-07.0R2 Moved requirement related to P_2 to new 3.1.2.1.5.1.2.3 below. Modified the numbering of this paragraph to make it a subparagraph to the Mode A/C-only all-call.

3.1.2.1.5.1.2.3 *Sidelobe suppression*. The pulse interval between P_1 and P_2 shall be 2 plus or minus 0.04 microseconds. Amplitude of P_2 shall be in accordance with 3.1.1.5.

Note 1. – Sidelobe suppression is required for SSR interrogators per 2.1.2.4.1. ACAS and multilateration system interrogations may or may not include the P_2 pulse.

Note 2.— When used, P_2 is additionally radiated to prevent replies from aircraft in the side and back lobes of the antenna.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Moved requirement related to P_2 to new 3.1.2.1.5.1.2.3 below. Modified the numbering of this paragraph to make it a subparagraph to the Mode A/C-only all-call. Separated requirements related to sidelobe suppression and added note to clarify that P_2 is an optional part of the Mode A/C-only all-call.

Origin:	**Rationale:**
SP/5	The amendment (3.1.2.1.5.1.4) is relating to P4 amplitude tolerance (interrogation). Review of the P4 acceptance/rejection criteria was performed to attempt to address observed behaviour that shows there are occurrences of Mode S transponders replying Mode A/C to short P4 interrogations, causing dual Mode S and Mode A/C tracks on systems utilizing Mode A/C Only All Call interrogation. The pulse amplitude and timing cases that potentially lead to transponder problems in detecting the short P4 pulse and replying ATCRBS were analysed. It was pointed out that interrogation signal levels in the transponder receiver minimum triggering level (MTL) region most commonly contribute to unwanted replies. To improve the issue, this amendment changes the P4 amplitude tolerance requirement, which allows an interrogator to transmit the P4 pulse with an increased amplitude, relative to the rest of the interrogation, to aid in transponder detection of the pulse. ASWG TSG WP 17-07.0R2: Due to additional modifications, all rationales need to be revisited.

…

3.1.2.1.5.2 Mode S interrogation.

Note 1.~~— 3.1.2.1.5.2 Mode S interrogation.~~ The Mode S interrogation is defined as ~~shall consist of three pulses:~~ P1, P2 and P6 as shown in Figure 3-4.

Note 2.— P6 is preceded by a P1 – P2 pair which suppresses replies from Mode A/C transponders to avoid synchronous garble due to random triggering by the Mode S interrogation. The sync phase reversal within P6 is the timing mark for demodulation of a series of time intervals (chips) of 0.25 microsecond duration. This series of chips starts 0.5 microsecond after the sync phase reversal and ends 0.5 microsecond before the trailing edge of P6. A phase reversal may or may not precede each chip to encode its binary information value.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Removed shall and moved this definition to a note per ASWG.

…

3.1.2.1.5.2.4 Intervals. The pulse interval between P1 and P2 shall be 2 plus or minus 0.04~~5~~ microsecond. The interval between the leading edge of P2 and the sync phase reversal of P6 shall be 2.75 plus or minus 0.04~~5~~ microsecond. The leading edge of P6 shall occur 1.25 plus or minus 0.04~~5~~ microsecond before the sync phase reversal. P5, if transmitted, shall be centred over the sync phase reversal; the leading edge of P5 shall occur 0.4 plus or minus 0.04~~5~~ microsecond before the sync phase reversal.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Changed to align with the value at the interrogator in the current Table 3-11

…

3.1.2.2 REPLY SIGNALS-IN-SPACE CHARACTERISTICS

Note — The paragraphs herein describe the signals-in-space at the antenna(s) of the transponder.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 No current guidance as to where these signals are specified

3.1.2.2.1 REPLY CARRIER FREQUENCY

3.1.2.2.1.1 *Standard PPM ~~R~~reply carrier frequency*. The carrier frequency of all standard Mode S PPM replies (downlink transmissions) ~~from transponders with Mode S capabilities~~ shall be 1 090 plus or minus 1 MHz.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 3.1.2.3.1.2.1 gives the definition for Standard PPM data in a Mode S reply. It is unclear why that reference was needed here and does not seem to provide the definition for Mode S capabilities as was implied.

3.1.2.2.1.2 *Phase overlay reply frequency*. The carrier frequency of all phase overlay reply transmissions as defined in 3.1.2.3.1.2.2 shall be 1 090 MHz plus or minus 25 KHz.

…

3.1.2.2.6 *Reply phase overlay characteristics*.

3.1.2.2.6.1 *Reply phase overlay modulation type*. The phase modulation reply transmission defined in 3.1.2.3.1.2.2 shall use 8PSK phase states to transmit 3 bits associated with a single phase state for each PPM data bit and in each of the four preamble pulses.

3.1.2.2.6.2 *Phase error tolerance*. The phase error of transmitted phase information shall be within 3.0 degrees RMS and 12.2 degrees peak for the duration of any 0.5 microsecond PPM reply pulse, excluding the leading and trailing edges of the pulse. When a one-microsecond pulse is transmitted as a result of a PPM ZERO data bit in the second half of one PPM bit interval followed by a PPM ONE bit in the first half of the next interval, the phase error for the phase information for each of the 2 phase states shall be within 3.0 degrees RMS and 12.2 degrees peak, except during the phase transition interval when a phase change is required between the 2 phase states, and the leading and trailing edges of the one-microsecond pulse. The phase error tolerance is in addition to the average frequency tolerance specified in 3.1.2.2.1.2, including the phase drift tolerance specified in 3.1.2.2.6.4.

Note.— During transmitter pulse turn-on and turn-off, the phase of the transmitted signal is typically not stable until the final RF output power is reached at the top portion of the pulse. It is not necessary to meet the accuracy requirement of the phase of the signal during the turn-on and turn-off portions of the pulse. The phase overlay reception algorithm should not rely on a constant phase during the transient portions of the pulse.

3.1.2.2.6.3 *Phase modulation during the phase transition interval*. For a 1.0 microsecond pulse which is formed by a PPM ZERO data bit followed by a PPM ONE data bit, the phase transition interval in which the phase is allowed to change between states shall be less than the 400 nanosecond interval commencing 200 nanoseconds prior to the PPM bit interval transition at the center of the 1.0 microsecond pulse.

Note 1.— The RF peak output power of any merged PPM pulses will not vary more than 1dB due to PO for a receiver bandwidth of 8 MHz when linearly applying PO across the 400 nanosecond phase transition interval.

Note 2.— The worst case for spectral growth is when the phase overlay frequency shifts are 180 degrees between symbols in 1 microsecond wide PPM data pulses as shown in Figure 3-x1. One method of reducing spectral growth in this case is to ensure the 180 degree phase transition is linear.

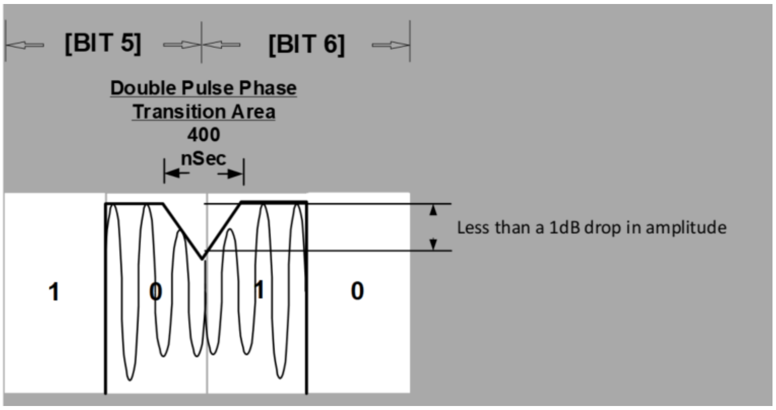


Figure 3-x1. Phase overlay one microsecond phase transition area

3.1.2.2.6.4 *Phase drift*. The peak phase drift due to transmitter frequency drift shall be within ±43 degrees for the entire message duration. The phase drift tolerance is in addition to the average frequency tolerance specified in 3.1.2.2.1.2.

3.1.2.2.6.5 *Reply spectrum*. The reply spectrum defined in 3.1.2.1.2 shall be met when phase overlay transmissions are active.

3.1.2.3 MODE S DATA STRUCTURE

…

3.1.2.3.1.2 *Reply data.*

3.1.2.3.1.2.1 *Standard PPM data*. The reply data block shall consist of 56 or 112 data bits formed by binary pulse position modulation encoding of the reply data as described in 3.1.2.2.5.1.2. A pulse transmitted in the first half of the interval shall represent a binary ONE whereas a pulse transmitted in the second half shall represent a binary ZERO.

3.1.2.3.1.2.2 *Phase overlay modulated data*. For phase overlay modulated signals, the PPM reply data shall additionally contain 8PSK modulated data within the bit interval containing the pulse, either the first half or the second half of the interval as per 3.1.2.3.1.2.1.

3.1.2.3.1.2.2.1 *Phase overlay data definition.* In addition to the binary ONE or binary ZERO represented by PPM, each data interval shall consist of 3 additional bit values representing the phase modulated reply data as determined by the encoded phase of the pulse in the bit interval as shown in Table 3-x1.

Phase Relative to Sync Reference (Degrees)	Binary Value MSB - LSB
0	000
45	001
90	010
135	011
180	100
225	101
270	110
315	111

Table 3-x1. Phase overlay data definition

3.1.2.3.1.2.2.2 S*ync phase reference pulses.* The reference sync phase shall be encoded in the four preamble pulses and the data pulses of the first four PPM data bits by maintaining constant phase for these pulses.

3.1.2.3.1.2.2.3 *Phase reference*. The reference phase shall represent zero degrees. This reference established by the data pulses in 3.1.2.3.1.2.2.2 is used to establish the phase for subsequent phase state determination.

…

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.

…

3.1.2.3.2.5 *Phase overlay reply data formats*. An overview of the transmitted phase overlay data message structure is as shown in Figure 3-x2.

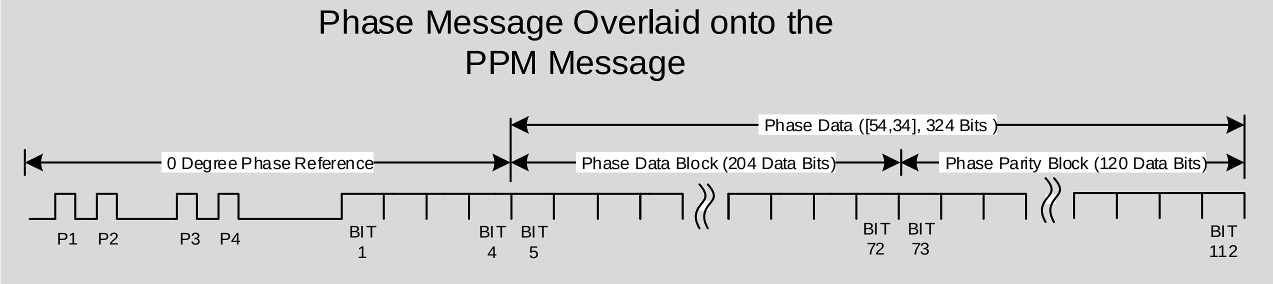


Figure 3-x2. Phase overlay message structure

3.1.2.3.2.5.1 *Phase overlay message data.* Phase data (PD) message bits shall be contained in bits 1 through 204 of the 324 bit phase data message. If phase overlay is not enabled for the reply or extended squitter, the message data field shall be zero filled.

3.1.2.3.2.5.2 *Phase overlay message type field.* Phase overlay bits 1 through 8 of the 324 bit phase data message shall contain the message type defining the PO message as shown in Table 3-x2

Message Type Value	Forward Error Correction	Meaning
0	N/A	No Data
1	RS	ADS-B State and Status Message
2		Mode S GICB Data
3		Interrogation/Reply Monitor Message
4		Test Message
5		DF-18 (ADS-R, ADS-SLR, TIS-B)
6		Undefined
7	LDPC	ADS-B State and Status Message
8		Mode S GICB Data
9		Interrogation/Reply Monitor Message
10		Test Message
11		DF-18 (ADS-R, ADS-SLR, TIS-B)
12		Undefined
13 – 255	Reserved	

Table 3-x2. Phase overlay message type field definition

Note .— The data format of the ADS-B State and Status Message, phase overlay Mode S GICB Data Messages and *phase overlay Interrogation/Reply Monitor Messages is specified in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).Furthermore, ADS-R, ADS-SLR and TIS-B are also described in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.3.2.5.3 *Phase overlay parity correction data.* Phase overlay bits 205 through 324 of the phase data message shall contain the 120 bit forward error correction (FEC) data defined in 3.1.2.3.2.5.3.1 and 3.1.2.3.2.5.3.2.

3.1.2.3.2.5.3.1 *Reed-Solomon.* When transmitting phase overlay message types 1-6 (RS Message Type Block), the transmitted phase overlay shall use a Reed-Solomon RS (54, 34) code with 6-bit symbols where two adjacent phase states (two adjacent PPM pulse data bits) are used as one 6 bit symbol (3 phase bits per 1 PPM bit). The RS (54, 34) code is shortened from a 63 symbol (2N-1) code. The first nine 6-bit symbols of the 63 symbol code that is used for the RS (54, 34) code shall have all bits set to zero. The Reed-Solomon shall use a generator polynomial start value of 1 to compute the parity error correction value. The Reed-Solomon shall use a field polynomial of x6 + x + 1. An example Reed-Solomon encoding is shown in Figure 3-x3.

Example: Phase Message Data (204 bits) (Octal)
044321263611527467577334565141662503102011064254702325715737042214$64_8$

Example: Corresponding Phase Parity Data (120 bits) (Octal)
Data (1-120)
02443416354341417177327342735007055660$22_8$

Figure 3-x3. Example phase overlay Reed-Solomon encoding

3.1.2.3.2.5.3.2 *Low Density Parity Code (LDPC).* When transmitting phase overlay message types 7-12 (LDPC Message Type Block), the transmitted phase overlay parity data shall be established by a cyclic LDPC (54, 34) code with 6 blocks of binary data as shown in table 3-x3. Each block is 54 bits total and is input to the LDPC parity check matrix independently. After encoding the parity of each block, the message and parity bits are assembled back in order.

Block #	Phase Message Data Bit (34 bits)	Phase Parity Correction Data Bit (20 bits)
1	1 – 34	205 – 224
2	35 – 68	225 – 244
3	69 – 102	245 – 264
4	103 – 136	265 – 284
5	137 – 170	285 – 304
6	171 – 204	305 – 324

Table 3-x3. Phase overlay LDPC data structure

The LDPC encoder shall use a field polynomial of x^20+x^18+x^11+x^9+x^2+1, which generates the parity check matrix as shown in Table 3-x4.

	1	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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0
2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1

Table 3-x4. Phase overlay LDPC parity check matrix

Note.— Figure 3-x4 is an example data field and the corresponding phase parity data which is generated when processed per the defined LDPC (54, 34) code.

Example: Phase Message Data (204 bits) (Octal)
$0443212636115274675773345651416625031020110642547023257157370422146 4_8$

Example: Corresponding Phase Parity Data (120 bits) (Octal)
Data (1-120)
$337107412613725477727525745243664205457 3_8$

Figure 3-x4. Example phase overlay LDPC encoding

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.2.1 to table 3-x4. Phase overlay LDPC parity check matrix) are relating to phase overlay capability. Changes implemented in ADS-B version 3 and related Mode S transponder functionality increase the future capacity and efficiency of the 1090 MHz frequency on which transponders and extended squitter operate. Since the ability to add additional messages and data is limited by the current capacity of the link, the phase overlay technique, which provides additional data within existing messages, is proposed to be added. Although the capability is optional, it is introduced so that industry can begin producing equipment that can readily incorporate the capability. Also the amendment to 3.1.2.3.2.1.4 is proposed to remove mode A/C/S interrogation.

…

3.1.2.4.1.1.1 *Mode A and Mode C interrogation recognition.* A Mode A or Mode C interrogation shall be recognized when a P_1 – P_3 pulse pair meeting the requirements of 3.1.1.4 has been received, and the leading edge of a P_4 pulse with an amplitude that is greater than a level 6 dB below the amplitude of P_3 is not received within the interval from 1.3~~7~~ to 2.~~3~~7 microseconds following the leading edge of P_3.

~~If a P_1 – P_2 suppression pair and a Mode A or Mode C interrogation are recognized simultaneously, the transponder shall be suppressed. An interrogation shall not be recognized as Mode A or Mode C if the transponder is in suppression (3.1.2.4.2). If a Mode A and a Mode C interrogation are recognized simultaneously the transponder shall complete the transaction cycle as if only a Mode C interrogation had been recognized.~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Moved to 3.1.1.7.16.

3.1.2.4.1.1.2 *Intermode interrogation recognition.*

3.1.2.4.1.1.2.1 ~~An intermode~~ A Mode A/C-only all-call interrogation shall be recognized when the requirements of 3.1.1.7.1 are met, ~~a P_1 – P_3 – P_4 pulse triplet meeting the requirements of 3.1.2.1.5.1.2 is received~~, with a P_4 pulse being of any duration greater than 0.7 microseconds and occurring 2 ± 0.1 microseconds from P_3.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 The currently referenced paragraph just points to a figure with no tolerances. This is an unclear and untestable requirement.

3.1.2.4.1.1.2.2 A Mode A/C-only all-call interrogation shall be recognized if the received power of P4 is above P3 minus 1 dB at any signal level of P1P3 from MTL+1 dB to -21dBm.

3.1.2.4.1.1.2.3 An interrogation shall not be recognized as an intermode interrogation if:

a) the received amplitude of the pulse in the P_4 position is smaller than 6 dB below the amplitude of P_3; or

b) the pulse interval between P_3 and P_4 is larger than 2.7~~3~~ microseconds or shorter than 1.3~~7~~ microseconds; or

c) the received amplitude of P_1 and P_3 is between MTL and –45 dBm and the pulse duration of P_1 or P_3 is less than 0.3 microsecond; or

d) the transponder is in suppression (3.1.2.4.2) ;or

e) the pulse interval between P_1 and P_3 differs from the nominal spacing by 1.0 microseconds or more; or

f) the pulse duration of P_4 is less than 0.3 microsecond

~~If a P_1 – P_2 suppression pair and a Mode A or Mode C intermode interrogation are recognized simultaneously the transponder shall be suppressed.~~

…

3.1.2.4.1.2.2 *Intermode interrogation acceptance*

3.1.2.4.1.2.2.1 *Mode A/C/S all-call interrogation acceptance.* ~~A Mode A/C/S all-call interrogation shall be accepted if the trailing edge of P_4 is received within 3.45 to 3.75 microseconds following the leading edge of P_3 and no lockout condition (3.1.2.6.9) prevents acceptance. A Mode A/C/S all-call shall not be accepted if the trailing edge of P_4 is received earlier than 3.3 or later than 4.2 microseconds following the leading edge of P_3, or if a lockout condition (3.1.2.6.9) prevents acceptance.~~

Note .- Mode A/C/S all-call interrogations are no longer useable. If a transponder receives a Mode A/C/S all-call interrogation, it will be recognized as a Mode A/C-only all-call interrogation.

3.1.2.4.1.2.2.2 *Mode A/C-only all-call interrogation acceptance.* A Mode A/C-only all-call interrogation shall not be accepted by a Mode S transponder.

~~*Note.— The technical condition for non-acceptance of a Mode A/C-only all-call is given in the preceding paragraph by the requirement for rejecting an intermode interrogation with a* P_4 *pulse having a trailing edge following the leading edge of* P_3 *by less than 3.3 microseconds.*~~

…

~~3.1.2.4.1.3.1 Mode A and Mode C replies. A Mode A (Mode C) reply shall be transmitted as specified in 3.1.1.6 when a Mode A (Mode C) interrogation has been accepted.~~

~~3.1.2.4.1.3.2 *Mode S replies.* Replies to other than Mode A and Mode C interrogations shall be Mode S replies.~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Deletions of 3.1.2.4.1.3.1 and 3.1.2.4.1.3.2 are proposed. - This is not needed as 3.1.1 now applies to any transponder - This was never true for transponders that support other types of interrogations (like military modes).

3.1.2.4.1.3.1~~2.1~~ *Replies to intermode interrogations.* ~~A Mode S reply with downlink format 11 shall be transmitted in accordance with the provisions of 3.1.2.5.2.2 when a Mode A/C/S all-call interrogation has been accepted. Equipment certified on or after 1 January 2020 shall not reply to Intermode Mode A/C/S all-call interrogations.Mode S transponder certified on or after 1st January 2020 shall not reply to Intermode interrogations.~~

Note 1.— A Mode S reply with downlink format 11 is transmitted in accordance with the provisions of 3.1.2.5.2.2 when a Mode A/C/S all-call interrogation has been accepted by a transponder certified before 1st January 2020.

Note 2.— Since Mode S transponders do not accept Mode A/C-only all-call interrogations, no reply is generated.

3.1.2.4.1.3.2~~.2~~ Replies to Mode S interrogations. The information content of a Mode S reply shall reflect the conditions existing in the transponder after completion of all processing of the interrogation eliciting that reply. The correspondence between uplink and downlink formats shall be as summarized in Table 3-5

…

3.1.2.4.1.3.~~2.~~2.1 Replies to SSR Mode S-only all-call interrogations. The downlink format of the reply to a Mode Sonly all-call interrogation (if required) shall be DF = 11. The reply content and rules for determining the requirement to reply shall be as defined in 3.1.2.5.

…

3.1.2.4.1.3.~~2.~~2.2 Replies to surveillance and standard length communications interrogations. A Mode S reply shall be transmitted when a Mode S interrogation with UF = 4, 5, 20 or 21 and an aircraft address has been accepted. The contents of these interrogations and replies shall be as defined in 3.1.2.6.

…

3.1.2.4.1.3.~~2.~~2.3 Replies to extended length communications interrogations. A series of Mode S replies ranging in number from 0 to 16 shall be transmitted when a Mode S interrogation with UF = 24 has been accepted. The downlink format of the reply (if any) shall be DF = 24. Protocols defining the number and content of the replies shall be as defined in 3.1.2.7.

3.1.2.4.1.3.~~2.~~2.4 Replies to air-air surveillance interrogations. A Mode S reply shall be transmitted when a Mode S interrogation with UF = 0 and an aircraft address has been accepted. The contents of these interrogations and replies shall be as defined in 3.1.2.8.

3.1.2.4.2 *SUPPRESSION*

3.1.2.4.2.1 Effects of suppression. A Mode S capable transponder in suppression (3.1.1.7.4) shall not recognize Mode A, Mode C or intermode interrogations if either the P1 pulse alone or both the P1 and P3 pulses of the interrogation are received during the suppression interval. Suppression shall not affect the recognition of, acceptance of, or replies to Mode S interrogations.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Added the words “Mode S capable” for extra clarity.

3.1.2.4.2.2 *Suppression pairs.* The two-pulse Mode A/C suppression pair defined in 3.1.1.7.4.1 shall initiate 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.

Note.— The transponder may optionally initiate suppression from a $P_3 – P_4$ *pulse pair of a Mode A/C-only all-call interrogation according to the criteria of recognition of an intermode interrogation in Section 3.1.2.4.1.1.2. If t~~T~~he* $P_3 – P_4$ *pair of the Mode A/C-only all-call interrogation is processed as a suppression, the pulse pair 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.*

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.4.1.1.1 to 3.1.2.4.2.2) is related to removal of the capability from a Mode S transponder to reply to Mode A/C/S all-call interrogations (i.e. Long P4), while keeping minimum SARPs information to cover old legacy transponders. Since it was recognized that an important source of Mode S RF pollution on 1090 MHz is the DF=11 all call replies generated in response to wrongly detected inter-mode A/C/S all-call interrogations (long P4), amendment 89 of Annex 10 Volume IV introduced changes to eliminate the reply to Mode A/C/S all-call interrogations. However, such provisions were complicated by the impact that the changes have on detection of the Mode A/C-only all-call interrogation (short P4) and the lack of clarity in detection criteria for this type of interrogation created confusion. This PfA provided clarification on such provisions. The requirement with a date of applicability is moved to 2.1.5.4.7 for more clarity for State implementation action and easier management over time.

~~3.1.2.4.2.3 Suppression in presence of S_1 pulse shall be as defined in 3.1.1.7.4.3.~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 This is not needed as 3.1.1 now applies to any transponder

3.1.2.4.3 *Airborne vs. on-the-ground*

Note.— Certain fields in DF 4, 5, 11, 17, 20, and 21 messages are based on whether the aircraft is determined, by the transponder, to be on-the-ground or airborne. Transponders determine and express whether the aircraft is on-the-ground or airborne using multiple approaches. Level 2 and above transponders report a declared air/ground status via the CA field (see 3.1.2.5.2.2.1). All transponders report an effective air/ground state via the VS field (see 3.1.2.8.2.1). The effective air/ground state is also reflected in the FS field (see 3.1.2.6.5.1).

3.1.2.4.3.1 *Declared air/ground status determination.* Declared air/ground status shall be restricted to "on-the-ground", "airborne", or "unknown".

3.1.2.4.3.1.1 If an automatic means of determining the on-the-ground condition is available and indicates "on-the ground", the declared air/ground status shall be "on-the-ground".

3.1.2.4.3.1.2 If an automatic means of determining the on-the-ground condition is available and does not indicate "on-the ground", the declared air/ground status shall be "airborne".

3.1.2.4.3.1.3 If an automatic means of determining the on-the-ground condition is unavailable, the declared air/ground status shall be "unknown".

Note.— The declared air/ground status may be set by air/ground data input (see 3.1.2.10.5.1.3) provided by an automatic means of determining the on-the-ground condition. Automatic means of determining the on-the-ground condition may include, for example, a weight on wheels switch, a strut switch, or an airframe-specific air/ground algorithm output.

3.1.2.4.3.2 *Declared air/ground status validation.* Aircraft with an automatic means of determining the on-the-ground condition and whose transponders have access to at least one of ground speed, radio altitude or airspeed, shall perform the following validation check:

3.1.2.4.3.2.1 If an automatic means of determining the on-the-ground condition is available and indicates "on-the-ground", the declared air/ground status shall be changed to "airborne" if:

Ground Speed > Speed Threshold OR Airspeed > Speed Threshold OR Radio Altitude > 50 feet

Where Speed Threshold is the lesser of 100 knots or the typical rotation speed of the aircraft (if available).

Note 1.— If an automatic means of determining the on-the-ground condition is not available or the declared air/ground status is "airborne", no validation check is required.

Note 2.— Modern aircraft with integrated avionics suites commonly contain sophisticated algorithms for determining the declared air/ground status 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 the additional validation in this section.

3.1.2.4.3.3 *Effective air/ground state determination.* Effective air/ground state shall be restricted to "on-the-ground" or "airborne".

3.1.2.4.3.3.1 When the declared air/ground status is "airborne" or "unknown", the effective air/ground state shall be "airborne".

3.1.2.4.3.3.2 When the declared air/ground status is "on-the-ground", the effective air/ground state shall be "on-the-ground".

3.1.2.5 INTERMODE AND MODE S ALL-CALL TRANSACTIONS

3.1.2.5.1 *INTERMODE TRANSACTIONS*

Note.— ~~Intermode transactions permit the surveillance of Mode A/C-only aircraft and the acquisition of Mode S aircraft. The Mode A/C/S all-call interrogation allows Mode A/C-only and Mode S transponders to be interrogated by the same transmissions.~~ The Mode A/C-only all-call interrogation makes it possible to elicit replies only from Mode A/C transponders. In multisite scenarios, the interrogator must transmit its identifier code in the Mode S only all-call interrogation. Thus, a pair of Mode S-only and Mode A/C-only all-call interrogations are used. The intermode interrogations are defined in 3.1.2.1.5.1 and the corresponding interrogation-reply protocols are defined in 3.1.2.4.

…

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 multiple ~~two~~ II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.

Note 1.— 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 2.— Lockout on the II code value of 0 is used for non-selective all-call lockout (3.1.2.6.9.2)

…

3.1.2.5.2.1.3.1 Surveillance identifier (SI) code capability report. Transponders ~~which~~that process ~~the~~ SI codes (3.1.2.5.2.1.2.4) shall report this capability by setting bit 35 of the MB field of the data link capability report (3.1.2.6.10.2.2) to 1 ~~in~~(the surveillance identifier capability (SIC) subfield) ~~of the MB field of the data link capability report (3.1.2.6.10.2.2).~~

3.1.2.5.2.1.4 Operation based on lockout override

Note 1.— The Mode S-only all-call lockout override provides the basis for acquisition of Mode S aircraft for interrogators that either have not been assigned an ~~unique~~ IC (II or SI code) or cannot ensure that their lockout region will not overlap with the lockout region of any other interrogator using the same IC, due to their mobile or transient operation.(*~~for full Mode S operation (protected acquisition by ensuring that no other interrogator on the same IC can lock out the target in the same coverage area~~*).

Note 2.— Lockout override ~~is possible~~ can be achieved using any interrogator code by setting the probability of reply (3.1.2.5.2.1.1) code in the range of 8 – 1.2

Note 3.— An interrogator may be assigned any defined II or SI code for use with lockout override.

…

~~3.1.2.5.2.1.4.3 Field content for a selectively addressed interrogation used by an interrogator without an assigned interrogator code. An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit shall use the II code 0 to perform the selective interrogations. In this case, selectively addressed interrogations used in connection with acquisition using lockout override shall have interrogation field contents restricted as follows:~~

~~UF = 4, 5, 20 or 21~~
~~PC = 0~~
~~DI = 7~~
~~IIS = 0~~
~~LOS = 0 except as specified in 3.1.2.5.2.1.5~~
~~TMS = 0~~

~~3.1.2.5.2.1.4.4 An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit~~

~~using II code 0 shall not attempt to extract an air-initiated Comm-B message announced by DR = 1 or 3.~~

~~Note.— These restrictions permit surveillance transaction, GICB transaction and Comm-B broadcast extraction, but prevent the interrogation from making any changes to transponder multisite lockout or communications protocol states.~~

3.1.2.5.2.1.5 Supplementary acquisition ~~using II equals 0~~

Note 1.— The acquisition technique defined in 3.1.2.5.2.1.4 provides rapid acquisition for most aircraft. Due to the probabilistic nature of ~~the process~~acquiring aircraft with a reduced reply probability (3.1.2.5.2.1.4.1), it may take many interrogations to acquire the last aircraft of a large set of aircraft in the same beam dwell and near the same range (termed a local garble zone). Acquisition performance is greatly improved for the acquisition of these aircraft through the use of limited selective lockout ~~using II equals 0~~ referred to here as supplementary acquisition.

Note 2.— Supplementary acquisition consists of locking out acquired aircraft ~~to II=0~~ followed by acquisition by means of the Mode S-only all-call interrogation without lockout override ~~with II=0~~. Only the aircraft not yet acquired and not yet locked-out will reply resulting in an easier acquisition. More guidance material can be found in Doc 9924.

Note 3.— Supplementary acquisition used to augment operation based on lockout override (3.1.2.5.2.1.4) is possible using any assigned IC. If no IC has been assigned, supplementary acquisition uses II equals 0 (3.1.2.5.2.1.5.3).

3.1.2.5.2.1.5.1 Lockout within a beam dwell

3.1.2.5.2.1.5.1.1 **Recommendation**.— *When ~~II equals 0~~ lockout is used to supplement the acquisition method described in 3.1.2.5.2.1.4, all aircraft within the beam dwell of the aircraft being acquired should be commanded to lock out ~~to II equals 0~~, not just those in the garble zone.*

Note.— Lockout of all aircraft in the beam dwell will reduce the amount of all-call fruit replies generated to the ~~II equals 0~~ all-call interrogations.

3.1.2.5.2.1.5.2 Duration of lockout

3.1.2.5.2.1.5.2.1 Interrogators performing supplementary acquisition ~~using II equals 0~~ shall perform acquisition by transmitting a lockout command for no more than two consecutive scans to each of the aircraft already acquired in the beam dwell containing the garble zone and shall not repeat it before 48 seconds have elapsed.

Note.— Minimizing the lockout time reduces the probability of conflict with the acquisition activities of a neighbouring interrogator that is ~~also~~ using the same IC ~~II equals 0 for supplementary acquisition~~.

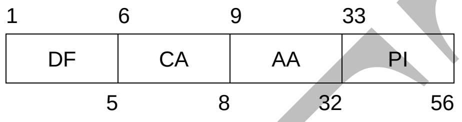
3.1.2.5.2.1.5.2.2 **Recommendation**.— *Mode S-only all-call interrogations ~~with II=0~~ for the purpose of supplementary acquisition should take place ~~within a garble zone~~ over ~~no more than two consecutive scans or~~ a maximum of 18 seconds.*

3.1.2.5.2.1.5.2.3 Interrogator without assigned interrogator code. An interrogator authorized to transmit that has not been assigned an IC and is unable to ensure that its lockout region will not overlap with the lockout region of another interrogator using the same IC shall use II code 0 for supplementary acquisition.

Origin:	**Rationale:**
SP/5	SP4-ASWG15-WP/15R2 (CPA10V4/40): II-SI Codes for Lockout Override, Supplementary Acquisition, and Non All-Call Acquisition Lockout override should be permitted on any interrogator code (IC) and not limited to II=0, as the transponder will disregard the IC. Supplementary acquisition, which is limited by definition, should also be allowed on any IC and not limited to II=0. Systems that do not use Mode S-only all-call interrogations, lockout protocol, or multisite protocol should be able to use any IC and not be limited to II=0 if not assigned an IC. For example, multilateration systems may desire to use certain ICs for improved monitoring.

…

3.1.2.5.2.2 *All-call reply, downlink format 11*



The reply to the Mode S-only all-call ~~or the Mode A/C/S all-call~~ interrogation shall be the Mode S all-call reply, downlink format 11. The format of this reply shall consist of these fields:

Note .— Mode S all-call reply may be transmitted by transponders certified before 1st January 2020 in response to Mode A/C/S all-call interrogation (see 2.1.5.4.7).

…

3.1.2.5.2.2.1 *CA: Capability.* This 3-bit (6-8) downlink field shall convey information on the transponder level, the additional information below, and shall be used in formats DF = 11 and DF = 17.

Coding	
0	signifies Level 1 transponder (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 Level 2 or above transponder and ability to set CA code 7 and a declared air/ground status of "on-the-ground" (see 3.1.2.8.6.7)~~on the ground~~
5	signifies Level 2 or above transponder and ability to set CA code 7 and a declared air/ground status of "airborne" (see 3.1.2.8.6.7)~~airborne~~
6	signifies Level 2 or above transponder and ability to set CA code 7 and a declared air/ground status of "unknown" (see 3.1.2.8.6.7)~~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~~

Note.—Refer to 2.1.5.2.3 for the status of Level 1 transponders.

~~When the conditions for CA code 7 are not satisfied, aircraft with Level 2 or above transponders:~~

~~a) that do not have automatic means to set the on-the-ground condition shall use CA code 6; and~~

~~b) with automatic on-the-ground determination shall use CA code 4 when on the ground and 5 when airborne.~~

Origin: SP/5	**Rationale:** These amendments (through from 3.1.2.4.3 to 3.1.2.4.3.3.2 and 3.1.2.5.2.2.1) are relating to air/ground determination and emitter category encoding. For Mode S transponders and 1090 MHz extended squitter ADS-B messages, certain fields and formats are based on whether the aircraft is assessed to be on the ground or in the air. The terms used to refer to whether the aircraft is on the ground or in the air, as determined by the transponder and/or ADS-B device, differed in various specifications developed by standard making organizations and Annex 10 Volume IV. This PfA will clarify terminologies used and resolve inconsistencies among those documents. The amendments (3.1.2.5.1 and 3.1.2.5.2.2) are related to removal of the capability from a Mode S transponder to reply to Mode A/C/S all-call interrogations (i.e. Long P4), while keeping minimum SARPs information to cover old legacy transponders.

…

3.1.2.5.3 Lockout protocol. The all-call lockout protocol defined in 3.1.2.6.9 shall be used by the interrogator with respect to an aircraft once the address of that specific aircraft has been acquired by an interrogator provided that:

— the interrogator is using an IC code different from zero; and

— the aircraft is located in an area where the interrogator is authorized to use lockout.

Note 1.— Following acquisition, a transponder is interrogated by discretely addressed interrogations as prescribed in 3.1.2.6~~,~~ and 3.1.2.7 ~~and 3.1.2.8~~ and the all-call lockout protocol is used to inhibit replies to further all-call interrogations.

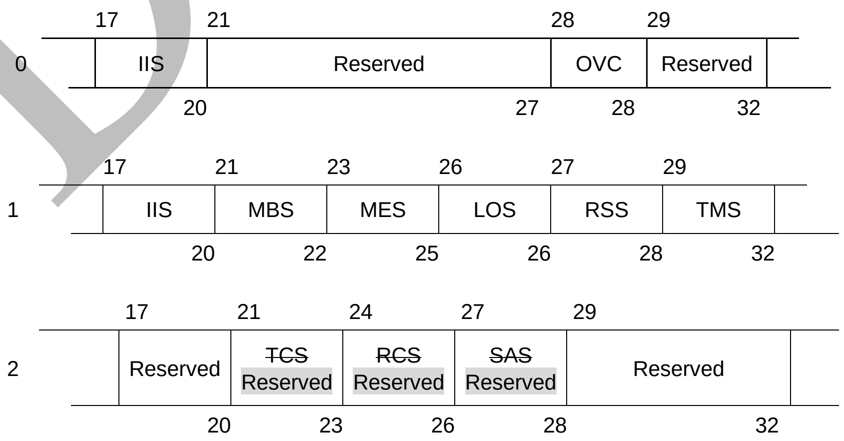
Origin: SP/5	**Rationale:** SP4-ASWG15-WP/15R2 (CPA10V4/40): II-SI Codes for Lockout Override, Supplementary Acquisition, and Non All-Call Acquisition

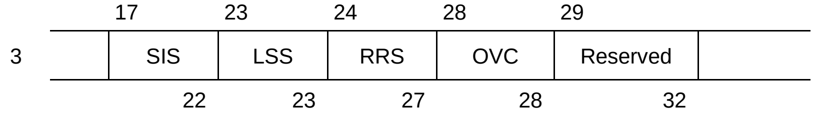
…

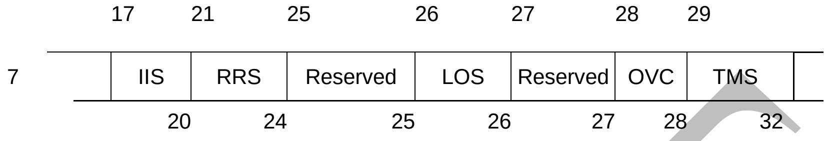
3.1.2.6.1.4 *SD: Special designator.* This 16-bit (17-32) uplink field shall contain control codes which depend on the coding in the DI field.

Note.— The special designator (SD) field is provided to accomplish the transfer of multisite, lockout and communications control information from the ground station to the transponder.

DI CODE *SD FIELD STRUCTURE*







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~~ the identifier code of the interrogator (3.1.2.5.2.1.2.3).

Note.— The IIS is intended to match the II code used by the interrogator in the Mode Sonly all-call interrogation (3.1.2.5.2.1). Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC in the IIS fields of their selective interrogations without coordination with neighbouring systems. The use of coordinated values differentiates interrogations transmitted by the different systems operating in the same area and facilitates the understanding of their respective contribution to the 1090 MHz environment.

Origin:	**Rationale:**
SP/5	SP4-ASWG15-WP/15R2 (CPA10V4/40): II-SI Codes for Lockout Override, Supplementary Acquisition, and Non All-Call Acquisition

…

f) If DI = 2:

SD is not assigned. The SD field when DI = 2 was previously used to control the squitter format type and rate reported by the transponder through the deprecated type control subfield (TCS), rate control subfield (RCS), and squitter antenna subfield (SAS) commands.

~~TCS, the 3-bit (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 Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations. The following codes have been assigned:~~

~~0 signifies no surface format types or reply inhibit command~~
~~1 signifies surface format types for the next 15 seconds (see 3.1.2.6.1.4.2)~~
~~2 signifies surface format types for the next 60 seconds (see 3.1.2.6.1.4.3)~~
~~3 signifies cancel surface format types and reply inhibit commands~~
~~4-7 reserved.~~

~~The transponder shall be able to accept a new command even though a prior command has not as yet timed out.~~

~~RCS, the 3-bit (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. The following codes have been assigned:~~

~~0 signifies no surface extended squitter rate command~~
~~1 signifies report high surface extended squitter rate for 60 seconds~~
~~2 signifies report low surface extended squitter rate for 60 seconds~~
~~3-7 reserved.~~

~~*Note 1.— The definition of high and low extended squitter rates is given in 3.1.2.8.6.4 and applies to the surface position, aircraft identification and category, and the operational status messages.*~~

~~*Note 2.— As stated in 3.1.2.8.5.2 d), acquisition squitters are transmitted when surface type format extended squitters are not being transmitted.*~~

~~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 the transponder is reporting the surface type formats, 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 status. 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~~ the surveillance identifier code of the interrogator (3.1.2.5.2.1.2.4).

Note.— The SIS is intended to match the SI code used by the interrogator in the Mode S-only allcall interrogation (3.1.2.5.2.1). Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC in the SIS fields of their selective interrogations without coordination with neighbouring systems. The use of coordinated values differentiates interrogations transmitted by the different systems operating in the same area and facilitates the understanding of their respective contribution to the 1090 MHz environment.…

~~3.1.2.6.1.4.2 *TCS subfield equal to one (1) in the SD field for extended squitters*. When the TCS subfield in the SD field is set equal to one (1), it shall signify the following:~~

~~a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 15 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1 f));~~

~~b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 15 seconds;~~

~~c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3 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; and~~

~~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.~~

~~3.1.2.6.1.4.3 *TCS subfield equal to two (2) in the SD field for extended squitters.* When the TCS subfield in the SD field is set equal to two (2), it shall signify the following:~~

~~a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 60 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1 f));~~

~~b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 60 seconds;~~

~~c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3 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; and~~

~~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.~~

Origin: SP/5	**Rationale:** In the amendments (through from 3.1.2.6.1.4.1 to 3.1.2.6.1.4.3) removal of the rate control subfield (RCS), type control subfield (TCS), and surface antenna subfield (SAS) are proposed. All are used within the special designator (SD) field used in UF=4, 5, 20, 21 messages in which the designator identification (DI) equals 2. These Mode S interrogation commands affecting airborne/surface format selection and transmission control (RCS, TCS, SAS) were considered undesirable controls of extended squitter and transponder operation. With the existing provisions, such controls could manipulate behaviour and operation of extended squitter and transponders in unintended ways.

…

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, vertical status (VS) indicates ~~aircraft is~~ "airborne"
1	signifies no alert and no SPI, VS indicates ~~aircraft is~~ "on-the-ground"
2	signifies alert, no SPI, VS indicates ~~aircraft is~~ "airborne"
3	signifies alert, no SPI, VS indicates ~~aircraft is~~ "on-the-ground"
4	signifies alert and SPI, VS indicates ~~aircraft is~~ "airborne" or "on-the-ground"
5	signifies no alert and SPI, VS indicates ~~aircraft is~~ "airborne" or "on-the-ground"
6	reserved
7	not assigned

Note.— The conditions which cause an alert are given in 3.1.2.6.10.1.1.

Origin: SP/5	**Rationale:** The amendment to 3.1.2.6.5.1 is proposed for ensuring consistent application of terminology.

…

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

…

e) If the M bit equals 1, the 12-bit field represented by bits 20 to 25 and 27 to 32~~31~~ shall be reserved for encoding altitude in metric units.

…

3.1.2.6.9.1.1 The multisite lockout command shall be transmitted in the SD field (3.1.2.6.1.4.1). 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 code equals 1 and 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. SI lockout shall be indicated by LSS equals 1 and the presence of a non-zero interrogator identifier in the SIS subfield of SD. 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 shall persist for an interval T_L (3.1.2.10.3.9) 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 (3.1.2.6.9.2).

Note 1.— Fifteen interrogators can send independent multisite II lockout commands. In addition, 63 interrogators can send independent SI lockout commands. Each of these lockout commands must be timed separately.

Note 2.— Multisite lockout (which only uses non-zero II codes) does not affect the response of the transponder to Mode S-only all-call interrogations containing II equals 0 ~~or to Mode A/C/S all-call interrogations~~.

3.1.2.6.9.2 *Non-selective all-call lockout*

Note 1.— In cases where the multisite lockout protocol for II codes is not required (e.g. there is no overlapping coverage or there is ground station coordination via ground-to-ground communications) the non-selective lockout protocol may be used.

On acceptance of an interrogation containing code 1 in the PC field, a transponder shall commence to lock out (i.e. not accept) ~~two types of all-call interrogations:~~

~~a)~~ the Mode S-only all-call (UF = 11), with II equals 0~~; and~~

~~b) the Mode A/C/S all-call of 3.1.2.1.5.1.1~~

Note 2 .— On acceptance of an interrogation containing code 1 in the PC field transponders certified before 1st January 2020 will also not reply to the Mode A/C/S all-call of 3.1.2.1.5.1.1 (see 2.1.5.4.6).

This lockout condition shall persist for an interval T_D (3.1.2.10.3.9) after the last receipt of the command. Non-selective lockout shall not prevent acceptance of a Mode S-only all-call interrogation containing PR codes 8 to 12.

Note 3.— Non-selective lockout does not affect the response of the transponder to Mode S-only all-call interrogations containing II not equal to 0.

Origin:	**Rationale:**
SP/5	The amendment to 3.1.2.6.5.4 e) is proposed for correction of bit numbering of the altitude field when encoded in metric units. The amendment to 3.1.2.6.9.2) is related to removal of the capability from a Mode S transponder to reply to Mode A/C/S all-call interrogations (i.e. Long P4), while keeping minimum SARPs information to cover old legacy transponders.

…

3.1.2.6.10.1.1.1 *Permanent alert condition.* The alert condition shall be maintained if the Mode A identity code is changed to ~~7500, 7600 or 7700~~ one of the Mode A codes defined in Emergency Mode A code set 1 or set 2.

3.1.2.6.10.1.1.1.1 Emergency Mode A code set 1 shall contain Mode A code 7500, 7600 or 7700.

3.1.2.6.10.1.1.1.2 Emergency Mode A code set 2 shall contain Mode A code 7400, 7500, 7600 or 7700.

…

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 those defined in Emergency Mode A code set 1 or set 2 listed in 3.1.2.6.10.1.1.1.

Origin: SP/5	**Rationale:** These amendments (3.1.2.6.10.1.1.1 and 3.1.2.6.10.1.1.3) are related to a special Mode A code indicating lost C2 link state. This proposed amendment is required to reflect the association of a specific Mode A code with UAS/RPAS lost C2 link state and maintain a permanent alert condition upon entry. The presentation of two sets of Mode A codes has been performed to facilitate the reference to one of the two sets for old and new transponders.

~~3.1.2.6.10.1.2 *Ground report.* The on-the-ground status of the aircraft shall be reported in the CA field (3.1.2.5.2.2.1), the FS field (3.1.2.6.5.1), and the VS field (3.1.2.8.2.1). If an automatic indication of the on-the-ground condition (e.g., from 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 on-the-ground status except as specified in 3.1.2.6.10.3.1. If such indication 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).

…

3.1.2.6.10.2.2.1.2 *Sources of data link capability*. Data link capability reports shall contain the capabilities provided by the transponder, the ADLP and the ACAS unit. ~~If external inputs are lost, the transponder shall zero the corresponding bits in the data link report.~~

3.1.2.6.10.2.2.1.3 The data link capability report shall contain information on the following capabilities as specified in Table 3-6.

Note.— The content of the datalink capability report differs between subnetwork versions. See Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871) for further details.*

…

3.1.2.6.10.2.2.3 *Zeroing of bits in the data link capability report*

~~If capability information to the transponder fails to provide an update at a rate of at least once every 4 seconds, the transponder shall insert ZERO in bits 41 to 56 of the data link capability report (transponder register 10_{16}).~~If a particular data field within the data link capability report (transponder register 10_{16}) cannot be updated within 8 seconds, the data field shall be set to ZERO.

Note 1.— ~~Bits 1 to 8 contain the BDS1 and BDS2 codes. Bits 16 and 37 to 40 contain ACAS capability information.~~ Bit 33 indicates the availability of aircraft identification data ~~and is set by the transponder when the data comes from a separate interface and not from the ADLP. Bit 35 is the SI code indication. All of these bits are inserted by the transponder.~~ See Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871) for further details.*

Note 2.- Transponders maintaining Aircraft Identification upon the loss of the interface providing Aircraft Identification do not reset to zero bit33 (2.1.5.4.10 and 2.1.5.4.11)

…

3.1.2.6.10.3 Basic dataflash protocol ~~*Validation of on-the-ground status declared by an automatic means*~~

Note.—The basic dataflash provides a protocol that allows the Mode S ground stations to be advised of changes that occur infrequently in various transponder registers of interest. The ground stations are advised of changes via Comm-B Broadcast of register 10_{16} *and then extract as needed or desired the register or registers of interest.*~~*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 state on which transponders have access to at least one of the parameters, ground speed, radio altitude or airspeed, 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:~~

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

3.1.2.6.10.3.1 *Basic dataflash capability report*. Transponders which monitor at least one of registers subject to basic dataflash protocol and report their changes through the basic dataflash protocol shall report this capability in the data link capability report (3.1.2.6.10.2.2.2) by setting bit 42 and bit 9 of the MB subfield to 1.

Note 1.— The registers for which changes can be reported using the basic dataflash protocol are defined in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871)*.

Note 2.— The setting of bit 9 to 1 indicates that the content of register 10_{16} *continues in register* 11_{16}*. This is what is expected when the basic dataflash option is implemented even if the basic dataflash state bits report zero because no information is provided to the monitored registers.*

3.1.2.6.10.3.2 *Mode S subnetwork version.* Transponders which monitor register changes and report their changes through the basic dataflash protocol shall support a Mode S subnetwork version 6 or above.

Note.— The basic dataflash protocol uses register formats that have been defined with Mode S Subnetwork version 6. More information can be found in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.6.10.3.3 Each basic dataflash register that is implemented shall have its contents updated at an interval not to exceed its update interval

Note.— The register update intervals are defined in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.6.10.3.4 *Register basic dataflash state.*

3.1.2.6.10.3.4.1 The basic dataflash state for each of the registers defined in register 11_{16} shall contain its associated monitoring states as follows:

Coding
0: Register not monitored or not implemented
1: Register monitored and implemented but no change yet detected
2: Register monitored and change 1 detected
3: Register monitored and change 2 detected

3.1.2.6.10.3.4.2 Each register shall be monitored for a change according to its update period.

Note.— The Register update periods are defined in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.6.10.3.4.3 Upon first entry into the monitored state, the transponder shall set the monitoring bits allocated in register 11_{16} for that basic dataflash register to "1" meaning register monitored and implemented but no change yet detected.

3.1.2.6.10.3.4.4 Once a change has been detected the basic dataflash state of the corresponding register shall be toggled between 2 and 3 with each change.

Note.— Toggle means if the register basic dataflash state was 2, at the next change it becomes 3, if it was 3 it becomes 2.

3.1.2.6.10.3.5 *Monitoring change and announcing a change to ground*

3.1.2.6.10.3.5.1 At intervals not exceeding 1 second the transponder shall determine if the contents of register 11_{16} have changed since the last update.

3.1.2.6.10.3.5.2 If the content of register 11_{16} has changed, bit 51 of register 10_{16} shall be toggled, and the F-Timer shall be started (see Table 3-9).

Note.— The toggling (1 → 0 or 0 →1) of bit51 in register 10_{16} will trigger a Comm-B broadcast of register 10_{16}.

3.1.2.6.10.3.5.3 All basic dataflash monitoring activity (comparison of register contents and setting of bits in register 11_{16}) shall be suspended until the F-timer expired.

Note 1.— The suspension of basic dataflash monitoring avoids the Comm-B broadcast channel saturation.

Note 2.— Dataflash monitoring suspension means that current content of monitored registers are memorized and the detection of a change with the new contents of these registers will re-start after the 30s timer. The monitored registers themselves continue to be updated at their update periodicity.

Note 3.— The use of basic dataflash protocol by ground systems is described in the Aeronautical Surveillance Manual *(Doc 9924). This allows reduction of periodic GICB extraction of registers changing rarely.*

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.6.10.1.2 to 3.1.2.6.10.3.5.3) are relating to provisions on air/ground determination, basic dataflash protocol and Data Link Capability Register Changes. Refer to page A-20 and page A-6 for air/ground determination and basic dataflash protocol. Due to additional capabilities included in the revisions to the transponder and extended squitter, there are needed changes in the Data Link Capability Report to announce these new capabilities. Requirement changing at specified dates have been moved to 2.1.5.4

…

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.— The transponder register allocation is specified in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871)~~*Annex 10, Volume III, Part I, Chapter 5, Table 5-24*~~.

…

3.1.2.6.11.2.6 *Phase overlay ground-initiated Comm-B.* When the reply contains the contents of the requested ground-initiated Comm-B register, for equipment supporting phase overlay on Mode S replies, phase data shall be encoded data in accordance with the register requested in the interrogation (i.e., requested BDS code) and as defined for that register.

3.1.2.6.11.2.6.1 *PO message type field.* The phase overlay message type field in PD data bits 1-8 shall be set to 2 for phase overlay Mode S GICB data with Reed-Solomon FEC and to 8 to indicate phase overlay Mode S GICB data with LDPC FEC.

3.1.2.6.11.2.6.2 *PO message subtype field.* PD data bits 9-12 shall contain the phase overlay message subtype field and is set to 1. The subfield is defined as shown in Table 3-x5.

Value	Meaning
0	No data
1	The PO data-block contains predefined values as defined for selected GICB registers
2 - 15	Reserved

Table 3-x5. Phase overlay message subtype field definition

Note.— Future UF codes may contain commands to force the transmission of other data in the phase overlay data block overlaid on Mode S long replies.

3.1.2.6.11.2.6.3 *PO-BDS field.* PD data bits 13-20 shall contain the BDS register number requested per paragraph 3.1.2.6.11.2.1.

3.1.2.6.11.2.6.4 *PO data-block field.* PD data bits 21-204 shall contain the content of the corresponding phase overlay data associated with the requested BDS register. When there is no phase overlay data defined for the requested BDS register, all bits shall be set to ZERO except the PO message type field is set to 2 or 8, PO message subtype=1, PO-BDS = BDS number of requested BDS register, and the 24-bit address is contained in the Aircraft Address (PD bits 181 through 204).

3.1.2.6.11.3 *Air-initiated Comm-B*

3.1.2.6.11.3.1 *General protocol.* The transponder shall announce the presence of an air-initiated Comm-B message with the insertion of code 1 in the DR field. To extract an air-initiated Comm-B message, the interrogator shall transmit a request for a Comm-B message reply in a subsequent interrogation with RR equal to 16 and, if DI equals 7, RRS must be equal to 0 (3.1.2.6.11.3.2.1 and 3.1.2.6.11.3.3.1). Receipt of this request code shall cause the transponder to transmit the air-initiated Comm-B message. If a command to transmit an air-initiated Comm-B message is received while no message is waiting to be transmitted, the reply shall contain all ZEROs in the MB field. When an air-initiated Comm-B message is transmitted, for equipment supporting phase overlay on Mode S replies, PD data bits 1-204 shall be set to ZERO.

The reply that delivers the message shall continue to contain code 1 in the DR field. After a Comm-B closeout has been accomplished, the message shall be cancelled and the DR code belonging to this message immediately removed. If another air-initiated Comm-B message is waiting to be transmitted, the transponder shall set the DR code to 1, so that the reply contains the announcement of this next message.

Note.— The announcement and cancellation protocol ensures that an air-initiated message will not be lost due to uplink or downlink failures that occur during the delivery process.

An interrogator that has either not been assigned an IC or cannot ensure that its interrogation region will not overlap with the interrogation region of another interrogator using the same IC shall not attempt to extract an air-initiated Comm-B message announced by DR equals 1 or 3.

3.1.2.6.11.3.1.1 *Phase overlay data.* When an air-initiated Comm-B message is transmitted, for equipment supporting phase overlay on Mode S replies, PD data bits 1-204 shall be set to ZERO.

…

3.1.2.6.11.3.4.1 The transponder shall be capable of storing two or more messages for each of the sixteen II codes: (1) an air-initiated or multisite-directed Comm-B message and (2) the contents of GICB registers 2 through 4.

~~*Note.— GICB registers 2 through 4 are used for the Comm-B linking protocol defined in the Mode S subnetwork SARPs (Annex 10, Volume III, Part I, Chapter 5).*~~

Origin:	**Rationale:**
SP/5	Additional provision under 3.1.2.6.11.3.1 came from CPA10V4/40 SP4-ASWG15-WP/15R2 ASWG TSG WP 17-07.0R2 Modified per a TSG request based on discussion of ASWG TSG WP 17-19.

…

3.1.2.6.11.4.2 *Extraction.*

3.1.2.6.11.4.2.1 To extract the broadcast message, an interrogator shall transmit RR equals 16 and DI not equal to 3 or 7 or RR equals 16 and DI equals 3 or 7 with RRS equals 0 in a subsequent interrogation.

3.1.2.6.11.4.2.2 For equipment supporting phase overlay on Mode S replies, PD message bits 1 through 204 shall contain the data as specified in 3.1.2.6.11.2.6 for the register that is broadcast or all ZEROs for other broadcast channels.

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.6.11.2.6 to 3.1.2.6.11.4.2.2) contains changes to include the technical performance requirements for the Phase Overlay capability on SSR Mode S replies.

…

3.1.2.8.2.1 *VS: Vertical status:* This 1-bit (6) downlink field shall indicate the effective air/ground state ~~status of the aircraft~~ (3.1.2.4.3.3~~6.10.1.2~~).

Coding

0 signifies that the effective air/ground state ~~aircraft~~ is “airborne”
1 signifies that the effective air/ground state ~~aircraft~~ is “on-the-ground”

…

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);

…

d) when the effective air/ground state is "on-the-ground", acquisition squitters shall ~~only~~ be transmitted only when ~~on the surface if the transponder is not reporting~~ the surface position ~~type of Mode S~~ extended squitter ADS-B messages are not being transmitted (3.1.2.8.6.3.2).

An acquisition squitter shall not be interrupted by link transactions or mutual suppression activity after the squitter transmission has begun.

Note~~ 1~~.— A mutual suppression system may be used to connect onboard equipment operating in the same frequency band in order to prevent mutual interference. Acquisition squitter action resumes as soon as practical after a mutual suppression interval.

~~*Note 2.— The surface report type may be selected automatically by the aircraft or by commands from a squitter ground station (3.1.2.8.6.7).*~~

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 the effective air/ground state is "airborne" (3.1.2.4.3.3~~8.6.7~~), the transponder shall transmit acquisition squitters alternately from the two antennas; and

b) when the effective air/ground state is "on-the-ground" ~~on the surface~~ (3.1.2.8.4.3.3~~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~~ from the top antenna only ~~shall be the default~~.

Note.— Acquisition squitters are not ~~e~~ transmitted ~~on the surface~~ if the effective air/ground state is "on-the-ground" (3.1.2.4.3.3) and the transponder is~~ reporting the surface type of extended squitter~~ transmitting surface position extended squitter ADS-B messages (3.1.2.8.6.4.3).

Origin: SP/5	**Rationale:** ADS-B version 3 enhances requirements for selection of airborne or surface message formats to transmit. These improvements are meant for fixed-wing aircraft without an automatic means of determining on the ground status (e.g., a landing gear weight on wheels switch). The requirements resulted from a State's monitoring of ADS-B transmissions, showing that a significant number of aircraft do not reliably determine the correct air/ground state, which reduces effectiveness and safety associated with ADS-B traffic applications. The amendments (through from 3.1.2.8.2.1 to 3.1.2.8.5.3) are proposed for ensuring consistent application of terminology and consistent with the concept of whether the aircraft is assessed to be "airborne" or "on-the-ground".

…

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. Extended squitter shall be supported by registers 05, 06, 07, 08, 09, 0A {HEX} and 61-6F {HEX} and shall conform to either version 0, version 1, ~~or~~ version 2 or version 3 message formats as described below:

a) Version 0 ES message formats and related requirements report surveillance quality by navigation uncertainty category (NUC), which can be an indication of either the accuracy or integrity of the navigation data used by ADS-B. However, there is no indication as to which of these, integrity or accuracy, the NUC value is providing an indication of.

b) Version 1 ES message formats and related requirements report surveillance accuracy and integrity separately as navigation accuracy category (NAC), navigation integrity category (NIC) and surveillance integrity level (SIL). Version 1 ES formats also include provisions for enhanced reporting of status information~~; and~~.

c) Version 2 ES message formats and related requirements contain the provisions of version 1 but further enhance integrity and parameter reporting. Version 2 ES formats separately report position source integrity from the integrity of the ADS-B transmitting equipment. Version 2 ES formats also separate vertical accuracy reporting from horizontal position accuracy, remove vertical integrity from position integrity, and provide for the reporting of the SSR Mode A code, GNSS antenna offset and additional horizontal position integrity values. Version 2 ES formats also modify the target state report to include selected altitude, selected heading, and barometric pressure setting; and~~.~~

d) Version 3 ES message formats and related requirements contain the provisions of version 2 and incorporate additional capabilities. Version 3 ES improves reporting of geometric altitude, supports the broadcast of weather and aircraft parameters in support of air-to-air and air-to-ground weather application as well as improves emitter category classifications. Version 3 also includes support for UAS/RPAS operations as well as position and velocity reporting to accommodate altitude and velocities not supported by previous versions. To enable monitoring of interrogation rates detected and transmitted reply rates by a transponder, version 3 supports the broadcast of such transponder activity. Version 3 additionally reports transponder antenna offset, an indication of Mode S reply rate limiting status as well as ACAS coordination capability reporting.

Note 1.— The formats and update rates of each register are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). The formats and update rates for individual squitters are defined by the version number of the extended squitter.*

Note 2.— The formats for the four~~three~~ different versions are interoperable. An extended squitter receiver can recognize and decode signals of its own version, as well as lower versions' message formats. The receiver, however, can decode higher version signals according to its own capability.

Note 3.— Guidance material on transponder register formats and data sources is included in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Origin:	**Rationale:**
SP/5	The amendment to 3.1.2.8.6.2 is proposed, which is related to the new extended squitter version, ADS-B version 3.

3.1.2.8.6.3 *Extended squitter types*

Note. – Extended squitter types described from 3.1.2.8.6.3.1 to 3.1.2.8.6.3.15 are defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc9871).*

3.1.2.8.6.3.1 *Airborne position squitter.* The airborne position extended squitter type shall use format DF = 17 with the contents of GICB register 05 {HEX} inserted in the ME field.

~~*Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 5 will cause the resulting reply to contain the airborne position message in its MB field.*~~

…

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), t~~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 message. When barometric altitude is reported, the 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 depend on the altitude type subfield (ATS) as specified in 3.1.2.8.6.8.2. Transponder insertion of barometric altitude data in the ACS subfield shall take place when the ATS subfield has the value of ZERO. Transponder insertion of barometric altitude data in ACS shall be inhibited when ATS has the value 1.~~

3.1.2.8.6.3.2 *Surface position squitter.* The surface position extended squitter type shall use format DF = 17 with the contents of GICB register 06 {HEX} inserted in the ME field.

~~*Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 6 will cause the resulting reply to contain the surface position message in its MB field..*~~

3.1.2.8.6.3.3 *Aircraft identification squitter.* The aircraft identification extended squitter type shall use format DF = 17 with the contents of GICB register 08 {HEX} inserted in the ME field.

~~*Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 8 will cause the resulting reply to contain the aircraft identification message in its MB field.*~~

3.1.2.8.6.3.4 *Airborne velocity squitter.* The airborne velocity extended squitter type shall use format DF = 17 with the contents of GICB register 09 {HEX} inserted in the ME field.

~~*Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 9 will cause the resulting reply to contain the airborne velocity message in its MB field.*~~

3.1.2.8.6.3.5 Aircraft operational status squitter. The aircraft operational status extended squitter type shall use format DF=17 with the contents of GICB register 65 {HEX} inserted in the ME field.

3.1.2.8.6.3.6 Target state and status squitter. The target state and status extended squitter type shall use format DF=17 with the contents of GICB register 62 {HEX} inserted in the ME field.

3.1.2.8.6.3.7 “Emergency/Priority status” squitter. The “Emergency/Priority Status” extended squitter type shall use format DF=17 with the contents of GICB register 61 {HEX} inserted in the ME field.

3.1.2.8.6.3.8 TCAS RA broadcast squitter. The TCAS RA broadcast extended squitter type shall use format DF=17 with the contents of GICB register 30 {HEX} inserted in the ME field.

Note.— In ADS-B Version 2, the TCAS RA broadcast extended squitter information was transmitted using the contents in GICB register 61 {HEX} subtype equal to 2.

3.1.2.8.6.3.9 HVA position squitter. The HVA position extended squitter type shall use format DF=17 with the contents of GICB register 6E {HEX} inserted in the ME field.

3.1.2.8.6.3.10 HVA velocity squitter. The HVA velocity extended squitter type shall use format DF=17 with the contents of GICB register 6F {HEX} inserted in the ME field.

3.1.2.8.6.3.11 “UAS/RPAS Contingency” Current/Next TCP squitters. The “UAS/RPAS Contingency” Current/Next CP extended squitter type shall use format DF=17 with the contents of GICB register 63 {HEX} to 64 {HEX} inserted in the ME field.

3.1.2.8.6.3.12 ADS-B Wx AIREP squitters. The ADS-B Wx AIREP extended squitter types shall use the contents of GICB register 68 {HEX} to 6A {HEX}, as applicable, to insert the appropriate aircraft or weather state information in the ME field.

3.1.2.8.6.3.13 ADS-B Wx PIREP squitters. The ADS-B Wx PIREP extended squitter types shall use the contents of GICB registers 6B {HEX} to 6D {HEX}, as applicable, to insert the appropriate aircraft or weather state information in the ME field.

3.1.2.8.6.3.14 Extended Squitter event-driven information. The event-driven message shall use format DF = 17 with the contents of GICB register 0A {HEX} inserted in the ME field.

Note.— Although labeled as Extended squitter, prior to version 3 this message would only be broadcast once each time the register was loaded with information. ADS-B version 3 removed the implementation of this register.

3.1.2.8.6.3.15 Interrogation/Reply Monitor squitters. The Interrogation/Reply Monitor squitter types shall use format DF = 17 with the contents of GICB registers 66 {HEX} to 67 {HEX} inserted in the ME field.

~~3.1.2.8.6.3.5 *Periodic status and event-driven squitters*~~

~~3.1.2.8.6.3.5.1 *Periodic status squitter.* The periodic status extended squitter types shall use format DF = 17 to convey aircraft status and other surveillance data. The aircraft operational status extended squitter type shall use the contents of GICB register 65 {HEX} inserted in the ME field. The target state and status extended squitter type shall use the contents of GICB register 62 {HEX} inserted in the ME field.~~

~~*Note 1.— A GICB request (3.1.2.6.11.2) containing RR equals 22 and DI equals 3 or 7 and RRS equals 5 will cause the resulting reply to contain the aircraft operational status message in its MB field.*~~

~~*Note 2.— A GICB request (3.1.2.6.11.2) containing RR equals 22 and DI equals 3 or 7 and RRS equals 2 will cause the resulting reply to contain the target state and status information in its MB field.*~~

~~3.1.2.8.6.3.5.2 *Event-driven squitter.* The event-driven extended squitter type shall use format DF = 17 with the contents of GICB register 0A {HEX} inserted in the ME field.~~

~~*Note.— A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 10 will cause the resulting reply to contain the event-driven message in its MB field.*~~

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.8.6.2 to 3.1.2.8.6.3.5.2) are related to the additional extended squitter messages introduced as part of ADS-B version 3. Current ADS-B versions 0 through 2 provide basic position data along with additional data elements that support various applications, which range from basic situational awareness to separation services. ADS-B version 3 will provide additional capabilities beyond those supported by earlier versions. These capabilities allow for enhancements in areas such as safety, equipment performance, airspace efficiency, and data reporting. ADS-B version 3 includes new capabilities such as: 1) Autonomous Distress Tracking support; 2) information to support future Interval Management operations; 3) broadcasting aircraft–based weather data; 4) Lost C2 Link State for UAS/RPAS; and 5) functionality to support commercial space and hypersonic aircraft operations. The ADS-B version 3 avionics standards also include several optional functions which lay the groundwork for future ADS-B improvements. It is important to note that a key requirement for ADS-B version 3 is that it is was designed to be backward compatible, to the extent possible, with ADS-B version 2.

3.1.2.8.6.4 *Extended squitter rate*

3.1.2.8.6.4.1 *Initialization*. At power up initialization, the transponder shall commence operation in a mode in which it does not transmit extended squitters. The initialization determination shall be made individually for each squitter type ~~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 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 both position and velocity extended squitters are not reportedorted~~.

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 the position squitter type stops for 60 seconds, broadcast will be discontinued until data insertion is resumed. Broadcast of airborne position squitters is not discontinued if barometric altitude data is available. Terminating broadcast of other squitter types~~ Initialization is described in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

~~*Note 2.— After timeout (3.1.2.8.6.6), the position 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 broadcast message format (see 3.1.2.8.6.7) ~~aircraft~~ is “airborne ” ~~(3.1.2.8.6.7)~~ and the HVA position squitter is not transmitted. Airborne position squitter transmissions 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 airborne position squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

Note.— Selection criteria for the airborne and HVA position squitters are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.6.4.3 *Surface position squitter rate.* Surface position squitter transmissions shall be emitted when the broadcast message format ~~aircraft is on the surface~~ (see 3.1.2.8.6.7) is “surface” 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 9.8 to 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 broadcast message format ~~aircraft is airborne~~ (see 3.1.2.8.6.7) is “‘airborne” and the HVA velocity squitter is not transmitted. Airborne velocity squitter transmissions 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 airborne velocity squitter, with the exceptions as specified in 3.1.2.8.6.4.7.

Note.— Selection criteria for the airborne and HVA velocity squitters are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.6.4.6 *Other extended ~~Periodic status and event-driven~~ squitter rates* Other extended squitters shall be emitted at rates consistent with the extended squitter message type and the associated extended squitter version number.

~~3.1.2.8.6.4.6.1 *Periodic status squitter rates.* The periodic status squitter types supported by a Mode S extended squitter transmitting system class, as specified in 5.1.1.2, shall be periodically emitted at defined intervals depending on the on-the-ground status and whether their content has changed.~~

Note.— Other extended squitter ~~The aircraft operational status extended squitter type and the target state and status extended squitter type~~ rates are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

~~3.1.2.8.6.4.6.2 *Event-driven squitter rate.* The event-driven squitter shall be transmitted once, each time that GICB register 0A {HEX} is loaded, while observing the delay conditions specified in 3.1.2.8.6.4.7. 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 due to 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.~~

Origin: SP/5	**Rationale:** The amendments (through from 3.1.2.8.6.4.1 to 3.1.2.8.6.4.6.2) are related to ADS-B version 3 extended squitter message Rates, message initiation/termination and message broadcast rates. Instead of including the new requirements in SARPs, these proposed amendments provides reference to Doc 9871 for the squitter rates for messages added to ADS-B Version 3. Furthermore, detailed existing technical specifications related to squitter rates and initiation messages are proposed to move to Doc 9871. Also, ADS-B version 3 includes optional High Velocity and/or Altitude (HVA) messages in support of commercial space vehicles and hypersonic vehicles that operate at velocities above the current maximum reporting capability of 1090 extended squitter. Current position and velocity messages cannot support vehicles operating at the high speeds of such vehicles, so new HVA messages were developed and are proposed to be incorporated into the SARPs. Additionally, these messages support altitude reporting for vehicles that operate above the normal reportable maximum altitude. The PfA included in this section also specified that the airborne and velocity squitters are not transmitted when the HVA squitters are active.

…

3.1.2.8.6.5 *Extended squitter antenna selection.* Transponders operating with antenna diversity (3.1.2.10.4) shall transmit extended squitters as follows:

a) when the broadcast message format~~airborne~~ (see 3.1.2.8.6.7) is “airborne”, the transponder shall transmit each type of extended squitter alternately from the two antennas; and

b) when the broadcast message format ~~on the surface~~ (see 3.1.2.8.6.7) is “on-the-ground”, the transponder shall transmit extended squitters from the top antenna only ~~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 condition.~~

3.1.2.8.6.6 *Register time-out and termination.* The transponder shall clear and terminate broadcast of information in extended squitter registers as required to prevent the reporting of outdated information.

Note.— Timeout and termination of extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.6.7 *Extended squitter ADS-B message formats*

Note 1.— DF = 17 message fields and formats are based on whether the aircraft is determined, by the transponder, to be on-the-ground or airborne. Level 2 and above transponders report declared air/ground status via the CA field in DF = 17 extended squitter ADS-B messages (see 3.1.2.5.2.2.1).

Note 2.— Extended squitter ADS-B messages are formatted based on the effective air/ground state or the broadcast message format. Effective air/ground state is set based on the declared air/ground status (see 3.1.2.4.3.3). Broadcast message format is set based on the declared air/ground status (see 3.1.2.4.3.3) and in fixed-wing aircraft may also incorporate the output of a broadcast message format algorithm (see 3.1.2.8.6.7.3).

Note 3.— The CA field reports the declared air/ground status (see 3.1.2.5.2.2.1). ACAS II acquires aircraft using squitters that contain the CA field. If an aircraft reports the declared air/ground status as "on-the-ground", that aircraft will not be interrogated by ACAS II in order to reduce unnecessary interrogation activity.

Note 4.— Use of the following technique may result in surface or airborne format extended squitter ADS-B messages being transmitted when the CA field indicates the declared air/ground status is "unknown" (CA code 6).

3.1.2.8.6.7.1 *Extended squitter ADS-B message format determination for ES version numbers 0 through 2.* Mode S transponders that broadcast version 0, 1, or 2, ES messages whose formats are not determined as described in 3.1.2.8.6.7.2, shall determine the extended squitter ADS-B message format based on the effective air/ground state (see 3.1.2.4.3.3).

3.1.2.8.6.7.1.1 If the effective air/ground state is "on-the-ground", the extended squitter ADS-B message format shall be "surface".

3.1.2.8.6.7.1.2 If the effective air/ground state is "airborne", the extended squitter ADS-B message format shall be "airborne", except as follows:

a) for aircraft whose emitter category (see Doc 9871) is Set "A" code 2, 3, 4, 5, or 6, or Set "B" code 7, the extended squitter ADS-B message format shall be "surface" if:

    i) if radio altitude and ground speed are available and airspeed is unavailable, and radio altitude indicates <50 feet and ground speed indicates <100 knots; or,

    ii) if radio altitude and airspeed are available and ground speed is unavailable, and radio altitude indicates <50 feet and airspeed indicates <100 knots; or,

    iii) if radio altitude, ground speed, and airspeed are available and radio altitude indicates <50 feet and both ground speed and airspeed indicate <100 knots

b) for aircraft whose emitter category (see Doc 9871) is Set "A" code 2, 3, 4, 5, or 6, or Set "B" code 7, the extended squitter ADS-B message format shall be "surface" if radio altitude is unavailable and available ground speed and airspeed both indicate <50 knots

c) for aircraft whose emitter category (see Doc 9871) is Set "C" code 1 or 2; the extended squitter ADS-B message format shall be "surface"

3.1.2.8.6.7.2 *Extended squitter ADS-B message format determination based on broadcast message format.* Mode S transponders shall use the broadcast message format to determine whether to report airborne or surface extended squitter ADS-B messages.

3.1.2.8.6.7.2.1 If subsequent to the validation in 3.1.2.4.3.2 the declared air/ground status is "airborne", the broadcast message format shall be "airborne".

3.1.2.8.6.7.2.2 If subsequent to the validation in 3.1.2.4.3.2 the declared air/ground status is "on-the-ground", the broadcast message format shall be "surface".

3.1.2.8.6.7.2.3 If the emitter category (see Doc 9871) is "Surface vehicle – emergency vehicle" or "Surface vehicle – service vehicle", the broadcast message format shall be "surface".

3.1.2.8.6.7.2.4 If subsequent to the validation in 3.1.2.4.3.2 the declared air/ground status is "unknown" and a broadcast message format algorithm is applicable (see 3.1.2.8.6.7.3), the broadcast message format shall be determined by the broadcast message format algorithm output.

3.1.2.8.6.7.2.5 If subsequent to the validation in 3.1.2.4.3.2 the declared air/ground status is "unknown" and a broadcast message format algorithm is not applicable (see 3.1.2.8.6.7.3), the broadcast message format shall be "airborne".

3.1.2.8.6.7.3 *Broadcast message format algorithm.*

Note.— Broadcast message format algorithm, if implemented, provides a means for fixed-wing aircraft, under certain conditions, to determine the broadcast message format using only sensor data available to the transponder. This is desirable to prevent aircraft without a means of automatically determining the on-the-ground condition from broadcasting an incorrect extended squitter ADS-B message format.

3.1.2.8.6.7.3.1 **Recommendation**.— *If not equipped with an automatic means of determining the on-the-ground condition, aircraft whose emitter category (see Doc 9871) is Set "A" code 1, 2, 3, or 5 should implement a broadcast message format algorithm.*

3.1.2.8.6.7.3.2 If implemented, broadcast message format algorithm requirements shall apply only to aircraft whose emitter category is Set "A" code 1, 2, 3, or 5.

3.1.2.8.6.7.3.3 *Reported broadcast message format.* If implemented, the broadcast message format algorithm shall provide a reported broadcast message format that is limited to "airborne" or "surface".

3.1.2.8.6.7.3.3.1 After start-up, if the broadcast message format algorithm does not update the reported broadcast message format within 300 seconds, or for more than 10 seconds after last reporting "surface" or "airborne", the reported broadcast message format shall be set to "airborne".

3.1.2.8.6.7.3.3.2 During taxi and takeoff operations, the broadcast message format algorithm shall correctly determine and update the reported broadcast message format prior to entering or within 5 seconds of exiting the runway transition zone, including while taxiing after landing.

Note.— A runway transition zone is defined as a rectangular box exactly enclosing a runway in the horizontal direction and extending to 100 feet altitude above ground level.

3.1.2.8.6.7.3.3.3 During inflight operations, the broadcast message format algorithm shall maintain a reported broadcast message format of "airborne" while remaining outside of any runway transition zone.

Note.—. For additional information regarding broadcast message format algorithm definitions, applicability, and performance, refer to RTCA DO-260C/ED-102B §2.2.3.2.2.1.4.

~~*Airborne/surface state determination.* Aircraft with an automatic means of determining on-the-ground conditions 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, except as specified in Table 3-7. Use of this table shall only be applicable to aircraft that are equipped to provide data for radio altitude AND, as a minimum, airspeed OR ground speed. Otherwise, aircraft in the specified categories that are only equipped to provide data for airspeed and ground speed shall broadcast the surface format if:~~

~~airspeed < 50 knots AND ground speed < 50 knots~~

~~Aircraft with or without such automatic on-the-ground determination shall use position message types as commanded by control codes in TCS (3.1.2.6.1.4.1 f)). After time-out of the TCS commands, control of airborne/surface determination shall revert to the means described above.~~

~~*Note 1.— Use of this technique may result in the surface position format being transmitted when the air-ground status in the CA fields indicates "airborne or on the ground".*~~

~~*Note 2.— Extended squitter ground stations determine aircraft airborne or on-the-ground status by monitoring aircraft position, altitude and ground speed. Aircraft determined to be on the ground that are not reporting the surface position message types will be commanded to report the surface formats via TCS (3.1.2.6.1.4.1 f)). The normal return to the airborne position message types is via a ground command to report airborne message types. To guard against loss of communications after take-off, commands to report the surface position message types automatically time-out.*~~

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.8.6.7 to 3.1.2.8.6.7.3.3.3) are relating to air/ground determination and emitter category encoding. The requirements resulted from a State’s monitoring of ADS-B transmissions, showing that a significant number of aircraft do not reliably determine the correct air/ground state, which reduces effectiveness and safety associated with ADS B traffic applications. ADS-B version 3 will enhance requirements for selection of airborne or surface message formats to transmit. These improvements are meant for fixed-wing aircraft without an automatic means of determining on the ground status (e.g., a landing gear weight on wheels switch). Also, the terms used to refer to whether the aircraft is on the ground or in the air, as determined by the transponder and/or ADS-B device, differed in various specifications developed by SMO and ICAO Annex 10 Volume IV. This PfA attempted to clarify terminologies used and resolve inconsistencies among those documents. Furthermore, those amendments deal with emitter category classifications and descriptions. Due to concerns raised by users that many of the version 2 emitter categories are conceived as misleading and if those are misused, those may cause safety issue, the updated reporting of emitter category in version 3 is proposed to address these concerns. For all aircraft types, ADS-B version 3 will provide an indication whether the aircraft is conducting manned or unmanned operations. Also there has been an issue in the handling of aircraft identification data, resulting in a potential difference between aircraft identification data received via ADS-B and ground interrogators. This PfA will resolve this issue and ensure that consistent data will be presented to controllers.

3.1.2.8.6.8 *Squitter status reporting*. Register 07 {HEX} shall be reserved in transponders conforming to ADS-B version 3 and later.

Note.— Technical provisions for squitter status reporting (Register 07 {HEX}) for ADS-B Version 2 and earlier can be found in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

~~A GICB request (3.1.2.6.11.2) containing RR equals 16 and DI equals 3 or 7 and RRS equals 7 shall cause the resulting reply to contain the squitter status report in its MB field.~~

~~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 the data format of register* 07_{16} *in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*~~

~~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 transponder register 07 {HEX}.~~

~~*Coding*~~

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

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

~~*Note.— Details of the contents of transponder registers 05 {HEX} and 07 {HEX} are shown in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*~~

3.1.2.8.6.9 *Surface squitter rate ~~control~~.* Surface position messages shall be initiated using the low squitter rate. The ~~S~~surface squitter broadcast rate ("high" or "low" as defined in 3.1.2.8.6.4.3) shall be determined as follows:

Note.— Transponders conforming to ADS-B version 2 and earlier examine the transmission rate subfield (TRS) to determine whether to transmit at the "high" or "low" rate. Relevant detailed technical provisions are specified in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

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~~the broadcast rate shall be changed from "high" to "low" when the navigation source position data has not changed more than 10 meters in any 15 minute interval ± 10 seconds;

Note.— It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.

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~~upon selecting the "low" broadcast rate, the transmission device shall save the position data at the time that the "low" rate was selected (including at initialization); and

c) ~~after time-out and in the absence of RCS codes 1 and 2, control shall return to TRS~~the broadcast rate shall be changed from "low" to "high" when the position of the transmission device has changed by 10 meters or more since the "low" rate was selected.

Note.— It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.

…

3.1.2.8.6.11 *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, 3.1.2.8.6.8.2)~~ and surveillance status into the appropriate fields of register 05 {HEX}. 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 read-out of register 05 {HEX} will yield exactly the same information as the AC field of a Mode S surveillance reply.

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.8.6.8 to 3.1.2.8.6.8.2 and 3.1.2.8.6.11) propose removal of legacy requirements related to Register 07 {HEX}, which contains two subfields related to altitude reporting and surface squitter rate. Amendment (3.1.2.8.6.9) is related to surface squitter broadcast rate. Surface squitter rate is reduced when aircraft/vehicles are not moving. However, tracking issues was identified, when aircraft/vehicles are broadcasting at the low rate and begin moving. In these situations, position updates are not sufficient to reliably track aircraft/vehicles and existing transition criteria tends to result in the low broadcast rate being selected. As a result, the requirements to transition from high rate to low rate have been changed. The time interval for switching from high broadcast rate to low rate when the vehicle is not moving is changed to15 minutes.

…

3.1.2.8.7.3.2 *ES/NT squitter types*

Note. - ES/NT squitter types described from 3.1.2.8.7.3.2.1 to 3.1.2.8.7.3.2.13 are defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc9871).*

3.1.2.8.7.3.2.1 *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.

3.1.2.8.7.3.2.2 *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.

3.1.2.8.7.3.2.3 *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.

3.1.2.8.7.3.2.4 *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.

3.1.2.8.7.3.2.5 Aircraft operational status squitter. The aircraft operational status extended squitter type shall use format DF=18 with the contents of GICB register 65 {HEX} inserted in the ME field.

3.1.2.8.7.3.2.6 Target state and status squitter. The target state and status extended squitter type shall use format DF=18 with the contents of GICB register 62 {HEX} inserted in the ME field.

3.1.2.8.7.3.2.7 “Emergency/Priority status” squitter. The “Emergency/Priority Status” extended squitter type shall use format DF=18 with the contents of GICB register 61 {HEX} inserted in the ME field.

3.1.2.8.7.3.2.8 HVA position squitter. The HVA position extended squitter type shall use format DF=18 with the contents of GICB register 6E {HEX} inserted in the ME field.

3.1.2.8.7.3.2.9 HVA velocity squitter. The HVA velocity extended squitter type shall use format DF=18 with the contents of GICB register 6F {HEX} inserted in the ME field.

3.1.2.8.7.3.2.10 “UAS/RPAS Contingency” Current/Next TCP squitter. The “UAS/RPAS Contingency” Current/Next CP extended squitter type shall use format DF=18 with the contents of GICB register 63 {HEX} to 64 {HEX} inserted in the ME field.

3.1.2.8.7.3.2.11 ADS-B Wx AIREP squitters. The ADS-B Wx AIREP extended squitter types shall use format DF=18 with the contents of GICB register 68 {HEX} to 6A {HEX}, as applicable, to insert the appropriate aircraft or weather state information in the ME field.

3.1.2.8.7.3.2.12 ADS-B Wx PIREP squitters. The ADS-B Wx PIREP extended squitter types shall use format DF=18 with the contents of GICB registers 6B {HEX} to 6D {HEX}, as applicable, to insert the appropriate aircraft or weather state information in the ME field.

3.1.2.8.7.3.2.13 Extended Squitter event-driven information. The event-driven message shall use format DF = 18 with the contents of GICB register 0A {HEX} inserted in the ME field.

Note.— Although labeled as Extended squitter, prior to version 3 this message would only be broadcast once each time the register was loaded with information. ADS-B version 3 removed the implementation of this register.

~~3.1.2.8.7.3.2.5 *Periodic status and event-driven squitters*~~

~~3.1.2.8.7.3.2.5.1 *Periodic status squitters.* The periodic status extended squitter types shall use format DF = 18 to convey~~

~~aircraft status and other surveillance data. The aircraft operational status extended squitter type shall use the format of GICB register 65 {HEX} as defined in 3.1.2.8.6.4.6.1 inserted in the ME field. The target state and status extended squitter type shall use the format of GICB register 62 {HEX} as defined in 3.1.2.8.6.4.6.1 inserted in the ME field.~~

~~3.1.2.8.7.3.2.5.2 *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.~~

Origin:	**Rationale:**
SP/5	These amendments (through from 3.1.2.8.7.3 to 3.1.2.8.7.3.2.5.2) are related to the additional extended squitter messages introduced as part of ADS-B version 3.

3.1.2.8.7.3.3 *ES/NT squitter rate*

3.1.2.8.7.3.3.1 *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 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 the position squitter type stops for 60 seconds, broadcast will cease until data insertion resumes, except for an ES/NT device ~~operating on the surface~~ when the broadcast message format (see 3.1.2.8.6.7) is "surface" (as specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871)). Broadcast of airborne position squitters is not discontinued if barometric altitude data is available. Terminating broadcast of other squitter types is described in Doc 9871*.

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

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

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

3.1.2.8.7.3.3.3 *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~~ the broadcast message format (see 3.1.2.8.6.7) is "airborne", the non-transponder device shall transmit each type of ES/NT squitter alternately from the two antennas; and

b) when ~~on the surface~~the broadcast message format (see 3.1.2.8.6.7) is "surface", the non-transponder device shall transmit ES/NT squitters from~~using~~ the top antenna only.

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.8.7.3.3.1 to 3.1.8.7.3.3.3) are proposed for ensuring consistent application of terminology and consistent with the concept of whether the aircraft is assessed to be "airborne" or "on-the-ground".

3.1.2.8.7.3.3.4 *Register timeout and termination*. The non-transponder device shall clear message fields and terminate broadcast of extended squitter messages as required to prevent the reporting of outdated information.

Note.— The timeout and termination of an extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

3.1.2.8.7.3.3.5 *Airborne/surface message format selection~~state determination~~*. Non-transponder devices shall report airborne or surface format extended squitter ADS-B messages as per the requirements in 3.1.2.8.6.7. ~~Aircraft with an automatic means of determining the on-the-ground state shall use this input to select whether to report the airborne or surface message types except as specified in 3.1.2.6.10.3.1. Aircraft without such means shall report the airborne type message.~~

Origin:	**Rationale:**
SP/5	The amendment (to 3.1.2.8.7.3.3.5) is relating to air/ground determination.

~~3.1.2.8.7.3.3.6 *Surface squitter rate control.* Aircraft motion shall be determined once per second. The surface squitter rate shall be set according to the results of this determination.~~

~~*Note.— The algorithm to determine aircraft motion is specified in the definition of register 07$_{16}$ in the* Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*~~

Origin:	**Rationale:**
SP/5	The amendment (3.1.2.8.7.3.3.6) proposes removal of legacy requirements related to surface squitter rate control.

…

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~~. DF = 19 can be used either as a squitter or as a reply.

…

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 for Military Use

Origin:	**Rationale:**
SP/5	The amendments (3.1.2.8.8 and 3.1.2.8.8.2) proposes clarifications on the downlink format 19, which cannot be used in lieu of DF=17 or DF=18, ADS-B Out extended squitter, but is reserved for military application.

3.1.2.8.9 *EXTENDED SQUITTER MAXIMUM TRANSMISSION RATE*

3.1.2.8.9.1 The maximum total number of full power extended squitters (DF = 17, 18 and 19) emitted by any extended squitter installation shall not exceed the following:

3.1.2.8.9.1.1 For a transponder capable of replying to intermode Mode A/C/S all-call interrogations:

a) 6.2 messages per second averaged over 60 seconds for nominal aircraft operations with no emergency and no ACAS RA activity, while not exceeding 11 messages being transmitted in any 1-second interval; or

b) 7.4 messages per second averaged over 60 seconds under an emergency and/or ACAS RA condition, while not exceeding 11 messages being transmitted in any 1-second interval.

3.1.2.8.9.1.2 For a transponder that does not have the capability to reply to intermode Mode A/C/S all-call interrogations or an extended squitter non-transponder device (2.1.5.1.8):

a) 6.7 messages per second averaged over 60 seconds for nominal aircraft operations with no temporary alert, no permanent alert, no emergency, no ACAS RA, and no UAS Contingency activity, while not exceeding 15 messages being transmitted in any 1-second interval; or,

b) 9.2 messages per second averaged over 60 seconds under a temporary/permanent alert, an emergency, an ACAS RA, and/or UAS Contingency condition, while not exceeding 19 messages being transmitted in any 1-second interval.

Note1.— It is anticipated that the transmission of any new messages required in addition to the capability specified above will be performed using the capacity provided by phase overlay.

Note 2.— The higher Extended Squitter rates are associated with transponders not capable of replying to intermode Mode A/C/S all call interrogations in order to keep an equilibrium on 1090 MHz link that is subject to overload. States are expected to ensure that this link is maintained through their transponder regulation (e.g TSO). The Minimum performance of such transponder can be found in RTCA DO-181F or EUROCAE ED-73F or later versions.

Note 3.— A higher extended squitter rate (9.2/s) is authorized when there is an emergency, a temporary/permanent alert (Mode A Code), an ACAS RA and/or an UAS contingency because such events are rare and are limited to very few platforms at the same time. Therefore, such events have a very limited effect on 1090 MHz usage.

Origin: SP/5	**Rationale:** The amendment to 3.1.2.8.9 is related to maximum extended squitter rate. ADS-B version 3 will provide additional capabilities beyond those supported by earlier versions, which allow for enhancements in areas such as safety, equipment performance, airspace efficiency, and data reporting. However, this will require increases of average extended squitter rate. Extensive discussion was made on this point which resulted in the proposed modification on the current maximum extended squitter rate requirements. This proposal is to split the current section 3.1.2.4.1.3.2.1 into two subsections in order to have clear reference to the capabilities of old transponders and new transponders. Specifically, the ability to reply or not reply to the Mode A/C/S/ All-Call interrogation determines if the transponder is eligible for the increased 1090ES rate. This is necessary that any increase in extended squitter rate is balanced by a reduction in transponder replies that result from transponder decoding of Mode A/C/S All-Call interrogations.

…

3.1.2.9.1.4 *Change of aircraft identification.* If the aircraft identification reported in the AIS subfield is changed in flight, the transponder shall report the new identification to the ground by use of the Comm-B broadcast message protocol of 3.1.2.6.11.4 for BDS1 = 2 (33 - 36) and BDS2 = 0 (37 - 40). The transponder shall initiate, generate and announce the revised aircraft identification~~ even if the interface providing flight identification is lost~~. The transponder shall ensure that the BDS code is set for the aircraft identification report in all cases, including a loss of the interface. ~~In this latter case, bits 41 - 88 shall contain all ZEROs.~~

Note 1.— The setting of the BDS code by the transponder ensures that a broadcast change of aircraft identification will contain the BDS code for all cases of ~~flight~~aircraft identification failure (e.g. the loss of the interface providing aircraft~~flight~~ identification).

Note 2.— In transponders certified on or prior to 1st January 2027*, bits 41-88 in register 20 {HEX} were set to zero upon loss of the interface providing aircraft identification. The transponder also initiated, generated, and announced the change in aircraft identification upon loss of interface.*

Origin:	**Rationale:**
SP/5	The amendment (3.1.2.9.1.4) is proposed to reflect a change in handling of Aircraft Identification data to not zero-out Aircraft ID in the transponder if the interface providing Aircraft ID is lost.

…

3.1.2.10 ESSENTIAL SYSTEM CHARACTERISTICS OF THE SSR MODE S AND INTERMODE TRANSPONDER CAPABILITIES

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Change to cover the capability rather than the whole system. Since intermode is generally considered to be a separate capability than Mode S, it has been added to the title.

3.1.2.10.1 *Transponder sensitivity and dynamic range.* Transponder sensitivity shall be defined in terms of a given interrogation signal input level and a given percentage of corresponding replies. Only correct replies containing the required bit pattern for the interrogation received shall be counted. Given an interrogation that requires a reply according to 3.1.2.4, the minimum triggering level, MTL, shall be defined as the minimum input power level for 90 per cent reply-to-interrogation ratio. The MTL shall be –74 dBm ±3 dB for Mode S interrogations (interrogations using P6)~~, and as defined in 3.1.1.7.5.1 b) for Mode A and C, and inter-mode interrogations~~. The reply-to-interrogation ratio of a Mode S transponder shall be:

a) at least 99 per cent for signal input levels between 3 dB above MTL and –21 dBm; and

b) no more than 10 per cent at signal input levels below –81 dBm.

Note.— Transponder sensitivity and output power are described in this section in terms of signal level at the terminals of the antenna. This gives the designer freedom to arrange the installation, optimizing cable length and receiver-transmitter design, and does not exclude receiver and/or transmitter components from becoming an integral part of the antenna subassembly.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 The reference back to 3.1.1 is now unnecessary once 3.1.1 applies to any system capable of ATCRBS. Removed “inter mode” as intermode interrogations are not replied to and therefore there is no need for a sensitivity requirement.

...

3.1.2.10.1.1.2 Reply ratio in the presence of pulse pair interference. Given a~~n~~ Mode S interrogation which requires a reply (3.1.2.4), the reply ratio of a transponder shall be at least 90 per cent in the presence of an interfering P1 – P2 pulse pair if the level of the interfering pulse pair is 9 dB or more below signal level for input signal levels between –68 dBm and –21 dBm and the P1 pulse of the interfering pair occurs no earlier than the P1 pulse of the Mode S signal.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Matches the wording from the paragraphs above and below for clarity.

...

3.1.2.10.1.1.4 Reply ratio in the presence of low-level in-band CW interference. In the presence of non-coherent CW interference at a frequency of 1 030 ±0.2 MHz at signal levels of 20 dB or more below the desired ~~Mode A/C~~ or Mode S interrogation signal level, the transponder shall reply correctly to at least 90 per cent of the interrogations.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 The ATCRBS requirement is covered by the new 3.1.1.7.17.

.....

~~3.1.2.10.1.1.5 Spurious response~~

~~3.1.2.10.1.1.5.1 Recommendation.— The response to signals not within the receiver pass band should be at least 60 dB below normal sensitivity.~~

~~3.1.2.10.1.1.5.2 For transponder designs first certified on or after 1 January 2011, the spurious Mode A/C reply ratio resulting from low level Mode S interrogations shall be no more than:~~

~~a) an average of 1 per cent in the input interrogation signal range between –81 dBm and the Mode S MTL; and~~

~~b) a maximum of 3 per cent at any given level in the input interrogation signal range between –81 dBm and the Mode S MTL.~~

~~*Note 1.— Failure to detect a low level Mode S interrogation can also result in the transponder decoding a three-pulse Mode A/C/S all-call interrogation. This would result in the transponder responding with a Mode S all-call (DF = 11) reply. The above requirement will also control these DF = 11 replies since it places a limit on the probability of failing to correctly detect the Mode S interrogation.*~~

~~*Note 2.— More information about issuing a type certificate for aircraft and separate design approval can be found in the* Airworthiness Manual (Doc 9760).~~

3.1.2.10.2.1 *Unwanted Output Power*

3.1.2.10.2.1.1 *Inactive state transponder output power.* When the transponder is in the inactive state the peak ~~pulse~~ power at 1 090 MHz plus or minus 3 MHz at the antenna end of the transmission line of the transponder shall not exceed –50 dBm when not installed with an ACAS unit or -70 dBm when installed with an ACAS unit. The inactive state is defined ~~to include~~ as the entire period between transmissions, less 10-microsecond transition periods preceding the first pulse and plus 10 microseconds transition period following the last pulse of the transmission. See figure 3-9.

Note.— Inactive state transponder power is constrained in this way to ensure that an aircraft, when located as near as 185 m (0.1 NM) to a Mode A/C or Mode S interrogator, does not cause interference to that installation. In certain applications of Mode S, airborne collision avoidance for example, where a 1 090 MHz transmitter and receiver are in the same aircraft, it ~~may be~~ is necessary to further constrain the inactive state transponder power.

3.1.2.10.2.1.2 *Active state transponder output power.*

3.1.2.10.2.1.2.1 The RF output power shall be less than or equal to the peak pulse power minus 50 dB for the interval starting 10 microseconds prior to the Mode S transmission and for the interval of 10 microseconds following a or Mode S transmission.

3.1.2.10.2.1.2.2 For intervals between transmitted pulses that are greater than 0.5 microseconds, the power level at the lowest point within the interval shall be 50 dB or more below the peak pulse power.

Note 1.- These power limitations protect 1090 MHz receivers from potential missed decodes when signals are received at close range and within desired detection range. In the absence of such limits, signal levels during non-pulse intervals can occur above receiver thresholds and can lead to unintended distortion of pulse positions or false pulse decodes preventing proper detection of transmitted signals. It also make more difficult for receivers to decode overlapped replies.

Note2..- It is possible that a signal transmitted 50dB below the peak pulse power can still affect high sensitivity receivers when transmitted in close range. More information is available in the Aeronautical Surveillance Manual *(Doc 9924).*

Note 3. – Information on how to verify unwanted output power can be found in RTCA DO-181F and EUROCAE ED-73F.

Note 4.- The presence of signal at a level of 50 dB or more below the peak power may not be measurable within the first 0.5 microseconds following the transmission of a pulse because of the allowed decay time.

Note 5 . – Transmitters compliant with RTCA DO-181F and EUROCAE ED-73F meet the requirement defined in 3.1.2.10.2.1.2 .

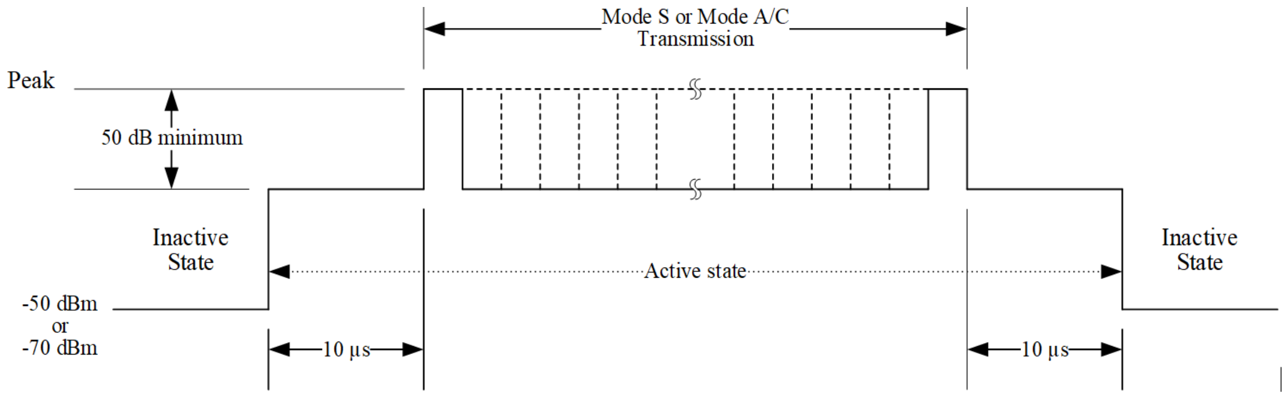


Figure 3-9: Unwanted Output Power

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.10.2.1 to figure 3-9) are proposed to ensure an acceptable level of transmissions before, between and after the pulses of a Mode A/C reply, a Mode S reply or an extended squitter in order to ensure the interoperability between transmitters and receivers of messages on the 1090MHz frequency. This also includes modifications to move requirements associated with a date to 2.1.5.4 to facilitate their management by States and ICAO. The text of the capability have been slightly modified to make easier the reference in the text now in 2.1.5.4.

…

Origin:	**Rationale:**
SP/5	The recommendation in section 3.1.2.10.2.2 is no longer valid and is not consistent with other ICAO Annex 10 Volume IV requirement on spurious emission or unwanted power transmission during inactive state. It is also not in line with the current spurious emission definition and associated ITU limits; hence its deletion is proposed.

3.1.2.10.3.2 *~~Mode S d~~Dead time.*

3.1.2.10.3.2.1 ~~Dead time shall be defined as~~ For all transponders, the time interval beginning at the end of a reply transmission and ending when the receiver ~~transponder~~ has regained sensitivity to within 3 dB of MTL (dead time)~~. Mode S transponders~~ shall not exceed~~have more than~~ 125 microseconds~~' dead time~~.

3.1.2.10.3.2.2 For transponder with improved dead time, the time interval beginning at the end of a reply transmission and ending when the receiver has regained sensitivity to within 3 dB of MTL (dead time) shall not exceed 20 microseconds.

…

~~3.1.2.10.3.4.1.3 All Mode S transponders installed on or after 1 January 1999 shall recover sensitivity to within 3 dB of MTL no later than 45 microseconds after receipt of the sync phase reversal following a Mode S interrogation that is not accepted (3.1.2.4.1.2) or that is accepted but requires no reply.~~

Origin:	**Rationale:**
SP/5	The amendments (through from 3.1.2.10.3.2 to 3.1.2.10.3.2.2) are provisions related to reduction of transponder dead time. It was pointed out that the current requirement related to transponder dead time is based on old technology and current transponders are much more capable than the dead time limit allowed by SARPs. Therefore, a change in the dead time (time interval from the end of a reply transmission to when the receiver has regained its sensitivity to within 3 dB of MTL) requirement for a Mode S transponder from 125 µs to 20 µs is proposed. This also includes modifications to move requirements (3.1.2.10.3.4.1.3) associated with a date to 2,1,5,4 to facilitate their management by States and ICAO. The text describing the capability have been adapted to make easier the reference to the characteristics in 2.1.5.4 section.

…

3.1.2.10.3.6 *Reply rate limiting*

Note.— Reply rate limiting is prescribed separately for Modes A and C and for Mode S.

3.1.2.10.3.6.1 *Mode S reply rate limiting.* ~~Reply rate limiting is not required for the Mode S formats of a transponder. If such limiting is incorporated for circuit protection, it~~

3.1.2.10.3.6.1.1 Mode S reply rate limiting shall permit the minimum reply rates required in 3.1.2.10.3.7.2 and 3.1.2.10.3.7.3.

Note.— Mode S transponders certified before 1 January 20xx have no requirement for Mode S reply rate limiting function, and may have a different implementation of this function.

3.1.2.10.3.6.1.2 *Mode S reply rate limiting type 1*

3.1.2.10.3.6.1.2.1 Mode S reply rate limiting shall be separate from Mode A and C reply rate limiting.

3.1.2.10.3.6.1.2.2 The Mode S reply rate limiting shall ensure the transponder does not cease to reply to valid Mode S interrogations for a period greater than 100 milliseconds.

3.1.2.10.3.6.1.2.3 The Mode S reply rate limiting shall limit the Mode S replies to a maximum reply rate of 180 Mode S replies per second or less.

Note.— The maximum reply rate limit can be less than the 180 specified here but is greater than the minimums specified in 3.1.2.10.3.7.3 .

3.1.2.10.3.6.1.2.4 The Mode S reply rate limiting shall be accomplished using methods other than sensitivity reduction.

Note.— Sensitivity-reduction rate limiting is prohibited due to the potential impact on ACAS.

3.1.2.10.3.6.1.2.5 The Mode S reply rate limiting function shall exclude the acquisition squitter (see 3.1.2.8.5) and extended squitter (see 3.1.2.8.6) transmissions.

3.1.2.10.3.6.1.2.6 The Mode S Reply Rate Limiting function shall process received interrogations regardless of the received antenna channel.

3.1.2.10.3.6.1.2.7 The Mode S Reply Rate Limiting function shall process received interrogations regardless of uplink format.

Note -. The Mode S reply rate limiting also includes replies to ACAS resolution and coordination messages.

3.1.2.10.3.6.1.2.8 **Recommendation**.— *The Mode S reply rate limiting should be accomplished stochastically.*

Origin	**Rationale**
SP/5	The amendments (through from 3.1.2.10.3.6.1.1 to 3.1.2.10.3.6.1.3.8) are requirements associated with the SSR Mode S reply rate limiting, which are technical measures, aiming at reducing 1 090 MHz congestion further, especially those are for protecting against complete loss of surveillance in areas where Mode S interrogations are high. This will for instance deal with the situation that happened in Europe in 2014. This also includes modifications to move the requirements associated with a date to 2.1.5.4 section to facilitate their management by States and ICAO.

3.1.2.10.3.6.2 Modes A and C reply rate limiting. ~~Reply rate limiting for Modes A and C shall be effected according to 3.1.1.7.9.1.~~ The Mode A and Mode C prescribed sensitivity reduction (3.1.1.7.9.2) shall not affect the Mode S performance of the transponder.

3.1.2.10.3.7 Minimum reply rate capability, Mode~~s A, C and~~ S

3.1.2.10.3.7.1 All reply rates specified in 3.1.2.10.3.7 shall be in addition to any squitter transmissions that the transponder is required to make.

~~3.1.2.10.3.7.2 Minimum reply rate capability, Modes A and C. The minimum reply rate capability for Modes A and C shall be in accordance with 3.1.1.7.9.~~

3.1.2.10.3.7.2~~3~~ Minimum reply rate capability, Mode S. A transponder capable of transmitting only short Mode S replies shall be able to generate replies at the following rates:

…

3.1.2.10.3.7.3~~4~~ Minimum Mode S ELM peak reply rat

…

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Since 3.1.1 applies to all transponders, the requirements above are no longer needed.

…

3.1.2.10.3.8 *Reply delay and jitter for Mode S*

~~*Note.— After an interrogation has been accepted and if a reply is required, this reply transmission begins after a fixed delay needed to carry out the protocols. Different values for this delay are assigned for Modes A and C, for Mode S and for Modes A/C/S all-call replies.*~~

~~3.1.2.10.3.8.1 *Reply delay and jitter for Modes A and C.* The reply delay and jitter for Modes A and C transactions shall be as prescribed in 3.1.1.7.10.~~

~~3.1.2.10.3.8.2 *Reply delay and jitter for Mode S.*~~ For all input signal levels between MTL and –21 dBm, the leading edge of the first preamble pulse of the reply (3.1.2.2.5.1.1) shall occur 128 plus or minus 0.25 microsecond after the sync phase reversal (3.1.2.1.5.2.2) of the received P_6. The jitter of the reply delay shall ~~not exceed~~ be less than or equal to 0.08 microsecond, peak (99.9 percentile).

Origin:	**Rationale:**
SP/5	Revision to language used for Mode S pulse jitter requirements to provide consistency with other signal characteristics requirements as well as improving overall clarity. Additional changes are proposed by ASWG TSG WP 17-07.0R2 Note was determined to not be helpful by the TSG. Since 3.1.1 applies to all transponders, this requirement is no longer needed.

~~3.1.2.10.3.8.3 *Reply delay and jitter for Modes A/C/S all call.* For all input signal levels between MTL +3 dB and –21 dBm the leading edge of the first preamble pulse of the reply (3.1.2.2.5.1.1) shall occur 128 plus or minus 0.5 microseconds after the leading edge of the P_4 pulse of the interrogation (3.1.2.1.5.1.1). Jitter shall not exceed 0.1 microsecond, peak (99.9 percentile).~~

~~*Note.— A peak jitter of 0.1 microsecond is consistent with the jitter prescribed in 3.1.1.7.10.*~~

3.1.2.10.3.9 *Timers.* Duration and features of timers shall be as shown in Table 3-9. All timers shall be capable of being restarted. On receipt of any start command, they shall run for their specified times. This shall occur 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 reset a timer shall cause the timer to stop running and to return to its initial state in preparation for a subsequent start command.

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 effective air/ground state is “on-the-ground”~~aircraft declares the on-the-ground state~~. It shall not be possible to inhibit replies to discretely addressed Mode S interrogations ~~regardless of whether the aircraft is airborne or on the ground~~.

Note.— Transponders certified on or before 1st January 2020 also inhibit replies to the Mode A/C/S all-call when the effective air/ground state is “on-the-ground” (see 2.1.5.4.8).

3.1.2.10.3.10.1 **Recommendation.—** *Aircraft should provide air/ground data~~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 from transponders with a Mode S capability shall~~should~~ be inhibited when the effective air/ground state is “on-the-ground” ~~aircraft is on the ground~~ to prevent interference when in close proximity to an interrogator or other aircraft.

Note.— 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.

Origin:	**Rationale:**
SP/5	These amendments (through fro 3.1.210.3.8 to 3.1.2.10.3.10.2) are relating to air/ground determination and removal of the capability from a Mode S transponder to reply to Mode A/C/S all call interrogations. This also includes modifications to move the requirements associated with a date to 2.1.5.4 to facilitate their management by States. Additional changes are proposed by ASWG TSG WP 17-07.0R2 Wording added to provide extra clarity that this function does not apply to ATCRBS only transponders.

…

3.1.2.10.4.1 *Radiation pattern.* The radiation pattern of ~~Mode S~~ antennas when installed on an aircraft shall be nominally equivalent to that of a quarter-wave monopole on a ground plane.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 It would not be normal to have separate antennas per mode.

…

3.1.2.10.4.3 Antenna selection. Mode S transponders equipped for diversity operation shall have the capability to evaluate a pulse sequence simultaneously received on both antenna channels to determine individually for each channel if the P1 pulse and the P2 pulse of a Mode S interrogation preamble meet the requirements for a Mode S interrogation as defined in 3.1.2.1 ~~and if the P1 pulse and the P3 pulse of a Mode A, Mode C or intermode interrogation meet the requirements for Mode A and Mode C interrogations as defined in 3.1.1~~.

…

3.1.2.10.4.3.1 If the two channels simultaneously receive at least a P1 – P2 pulse pair that meets the requirements for a Mode S interrogation~~, or a P1 – P3 pulse pair that meets the requirements for a Mode A or Mode C interrogation,~~ or if the two channels simultaneously accept a complete interrogation, the antenna at which the signal strength is greater shall be selected for the reception of the remainder (if any) of the interrogation and for the transmission of the reply.

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Mode A/C now covered in the new 3.1.1.7.19.3. Intermode can be removed as it is no longer replied to. Mode A/C now covered in the new 3.1.1.7.19.3.1.

…

3.1.2.10.5 *DATA PROCESSING AND INTERFACES*

3.1.2.10.5.1 *Direct data.* Direct data shall be those which are required for the surveillance protocol of the Mode S system.

3.1.2.10.5.1.1 *Fixed direct data.* Fixed direct data are data from the aircraft which do not change in flight and shall be:

a) the aircraft address (3.1.2.4.1.2.3.1.1 and 3.1.2.5.2.2.2);

b) the maximum airspeed (3.1.2.8.2.2); and

c) the registration marking if used for aircraft~~flight~~ identification (3.1.2.9.1.1).

…

3.1.2.10.5.1.3 *Variable direct data.* Variable direct data are data from the aircraft which can change in flight and shall be:

a) the Mode C altitude code (3.1.2.6.5.4);

b) the Mode A identity code (3.1.2.6.7.1);

c) ~~the on-the-ground condition~~ air/ground data (3.1.2.5.2.2.1, 3.1.2.6.5.1 and 3.1.2.8.2.1);

d) the aircraft identification if different from the registration marking (3.1.2.9.1.1); and

e) the SPI condition (3.1.2.6.10.1.3).

…

3.1.2.10.5.1.4.4 Interfaces shall be included to accept the pressure-altitude and air/ground data~~on-the-ground coding~~.

Note.— A specific interface design for the variable direct data is not prescribed.

Origin:	**Rationale:**
SP/5	The amendment (3.1.2.10.5.1.1) is related to aircraft identification register and the amendments (3.1.2.10.5.1.3 and 3.1.2.10.5.1.4.4) are relating to air/ground determination. Refer to rational in page A-44 and page A-20.

…

3.1.2.11 ESSENTIAL SYSTEM CHARACTERISTICS OF THE GROUND INTERROGATOR MODE S AND INTERMODE CAPABILITIES

~~Note.— To ensure that Mode S interrogator action is not detrimental to Mode A/C interrogators, performance limits exist for Mode S interrogators.~~

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 I don't think this note conveys the correct message. Mode A/C interrogators should not be assumed to be the most important users of the 1090 MHz spectrum. Mode S interrogators need to interoperate with a long list of users in this spectrum. (This rational needs to refine.)

~~…~~

~~3.1.2.11.1.1.1 Mode A/C/S all-call interrogations shall not be used.~~

~~*Note.— The replies to Mode A/C/S all-call interrogations are no longer supported by transponders certified on or after 1 January 2020. The replies to Mode A/C/S all-call interrogations have been removed to reduce the RF pollution generated by the replies triggered by the false detection of Mode A/C/S all-call interrogations within other types of interrogation.*~~

3.1.2.11.1.1.1 The interrogation repetition rate for ~~the Mode A/C/S all-call, used for acquisition, shall be less than 250 per second. This rate shall also apply to~~ the paired Mode S-only and Mode A/C-only all-call interrogations used for acquisition in the multisite mode shall be less than 250 per second.

3.1.2.11.1.1.2 Maximum number of Mode S all-call replies triggered by an interrogator. For aircraft that are not locked out, a Mode S interrogator shall not trigger, on average, more than 6 Mode S all-call replies per period of 200 ms and no more than 26 Mode S all-call replies counted over a period of 18 seconds.

Note .- When the rotating antenna of a Mode S ground station using Mode S all-call interrogations slows down up to a point where the maximum number of Mode S all-call replies could be exceeded, the RF transmissions need to be inhibited to *protect transponder operation as well as the 1090 MHz RF frequency. More information can be found in Doc 9924 Appendix D and M.*

…

~~3.1.2.11.4 Tolerances on transmitted signals. In order that the signal-in-space be received by the transponder as described in 3.1.2.1, the tolerances on the transmitted signal shall be as summarized in Table 3-11~~

3.1.2.11.4~~5~~ SPURIOUS RESPONSE

Recommendation.— The response to signals not within the passband should be at least 60 dB below normal sensitivity.

3.1.2.11.5~~6~~ Lockout coordination. A Mode S interrogator shall not be operated using all-call lockout until coordination has been achieved with all other operating Mode S interrogators having any overlapping coverage volume in order to ensure that no interrogator can be denied the acquisition of Mode S-equipped aircraft. If coordination is not possible due to system designs (for example, a mobile interrogator), the interrogator shall either use passive means of acquisition or operate using lockout override (3.1.2.5.2.1.4) with supplementary acquisition (3.1.2.5.2.1.5).

Note 1.— This coordination may be via ground network or by the allocation of interrogator ~~identifier (II)~~ codes and will involve regional agreements where coverage overlaps international boundaries.

Note 2.— Interrogators that do not use Mode S-only all-call interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC value in the IIS or SIS fields of their selective interrogations without a need for coordination with neighbouring systems.

…

3.1.2.11.6~~7~~ MOBILE INTERROGATORS

…

Origin: SP/5	**Rationale:** These amendments (through from 3.1.2.11.1.1.1 to 3.1.2.11.4) are relating to removal of the capability from a Mode S transponder to reply to Mode A/C/S all call interrogations. This also includes modifications to move the requirements associated with a date to 2.1.5.4 to facilitate their management by States. Additional texts and note 2 in new 3.1.2.11.5 came from CPA10V4/40 (SP4-ASWG15-WP/15R2) ASWG TSG WP 17-07.0R2 (Note under 3.1.2.11.1.1.2 was added per a TSG request). The requirement (3.1.2.11.4) is no longer needed as the SARPS will not specify interrogator signals as received by the transponder. A new Table 3-11 has been created and is now referenced in sections above.

…

TABLES FOR CHAPTER 3

Table 3-1. Pulse shapes —Interrogation pulse durations ~~Mode S and intermode~~ ~~interrogations~~

			(Rise time)		*(Decay time)*	
Pulse	*Duration*	*Duration tolerance*	*Min.*	*Max.*	*Min.*	*Max.*
P_1, P_2, P_3, P_5	0.80	±0.~~1~~09	0.05	0.10	0.05	0.20
P_4 (short)	0.80	±0.~~1~~09	0.05	0.10	0.05	0.20
~~P_4 (long)~~	~~1.6~~	~~±0.1~~	~~0.05~~	~~0.1~~	~~0.05~~	~~0.2~~

P_6 (short)	16.25	±0.20~~5~~	0.05	0.10	0.05	0.20
P_6 (long)	30.25	±0.20~~5~~	0.05	0.10	0.05	0.20
S_1	0.80	±0.10	0.05	0.10	0.05	0.20

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Title changed to be more generic so that ATCRBS and S1 are included (note they are already in the existing table). P_4 long is removed. Tolerances updated to align with Table 3-11.

Table 3-2. Pulse shapes — Mode S replies

		(Rise time)		*(Decay time)*	
Pulse duration	*Duration tolerance*	~~*Min.*~~	*Max.*	~~*Min.*~~	*Max.*
0.5	±0.05	~~0.05~~	0.1	~~0.05~~	0.2
1.0	±0.05	~~0.05~~	0.1	~~0.05~~	0.2

Origin:	**Rationale:**
SP/5	ASWG TSG WP 17-07.0R2 Removed minimum rise and decay times per TSG request to align with transponder MOPS.(rational needs to be refined.)

…

Table 3-4. Subfield definitions

Subfield			
Designator	*Function*	*Field*	*Reference*
ACS	Altitude code subfield	ME	3.1.2.8.6.3.1.2
AIS	Aircraft identification subfield	MB	3.1.2.9.1.1
~~ATS~~	~~Altitude type subfield~~	~~MB~~	~~3.1.2.8.6.8.2~~
BDS 1	Comm-B data selector subfield 1	MB	3.1.2.6.11.2.1
BDS 2	Comm-B data selector subfield 2	MB	3.1.2.6.11.2.1
IDS	Identifier designator subfield	UM	3.1.2.6.5.3.1
IIS	Interrogator identifier subfield	SD	3.1.2.6.1.4.1 a)
		UM	3.1.2.6.5.3.1
LOS	Lockout subfield	SD	3.1.2.6.1.4.1 d)
LSS	Lockout surveillance subfield	SD	3.1.2.6.1.4.1 g)
MBS	Multisite Comm-B subfield	SD	3.1.2.6.1.4.1 c)
MES	Multisite ELM subfield	SD	3.1.2.6.1.4.1 c)
OVC	Overlay control	SD	3.1.2.6.1.4.1 i)
~~RCS~~	~~Rate control subfield~~	~~SD~~	~~3.1.2.6.1.4.1 f)~~
RRS	Reply request subfield	SD	3.1.2.6.1.4.1 e) and g)
RSS	Reservation status subfield	SD	3.1.2.6.1.4.1 c)
~~SAS~~	~~Surface antenna subfield~~	~~SD~~	~~3.1.2.6.1.4.1 f)~~
SCS	Squitter capability subfield	MB	3.1.2.6.10.2.2.1
SIC	Surveillance identifier capability	MB	3.1.2.6.10.2.2.1
SIS	Surveillance identifier subfield	SD	3.1.2.6.1.4.1 g)
SRS	Segment request subfield	MC	3.1.2.7.7.2.1

Subfield			
Designator	*Function*	*Field*	*Reference*
SSS	Surveillance status subfield	ME	3.1.2.8.6.3.1.1
TAS	Transmission acknowledgement subfield	MD	3.1.2.7.4.2.6
~~TCS~~	~~Type control subfield~~	~~SD~~	~~3.1.2.6.1.4.1 f)~~
TMS	Tactical message subfield	SD	3.1.2.6.1.4.1 d)
~~TRS~~	~~Transmission rate subfield~~	~~MB~~	~~3.1.2.8.6.8.1~~

Origin: SP/5	**Rationale:** The amendment to table 3-4 subfield definitions proposes removal of legacy requirements.

…

Table 3-6. Table for the data link capability report (register 10_{16})

Subfields of register 10_{16}	*MB bits*	*Comm-B bits*
Continuation flag	9	41
Operational coordination message (OCM) transmit capability	10	42
Overlay command capability	15	47
ACAS capability	11-14,16 and 37-40	43-46, 48 and 69-72
Mode S subnetwork version number	17-23	49-55
Transponder enhanced protocol indicator	24	56
Specific services capability	25	57
Uplink ELM capability	26-28	58-60
Downlink ELM capability	29-32	61-64
Aircraft identification capability	33	65
Squitter capability subfield (SCS)	34	66
Surveillance identifier code capability (SIC)	35	67
Common usage GICB capability report	36	68
Basic dataflash capability	42	74
Phase overlay (PO) on extended squitter capability	43	75
Phase overlay (PO) on Mode S capability	44	76
Active transponder side indicator	49-50	81-82
Register 11_{16} data link capability (continuation) change indicator	51	83
~~Status of DTE sub-addresses 0 to 15~~	~~41-56~~	~~73-88~~

Note.— The "Status of DTE sub address 0 to 15" subfield that was previously defined as MB bits 41-56 in the data link capability report (register 10_{16}) is now defined as MB bits 41-56 in the data link capability report (extension) (register 11_{16}).

Additional information on all bits in the data link capability report can be found in Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Origin: SP/5	**Rationale:** The amendment (table 3-6) is related to Data Link Capability Register Changes.

~~Table 3-7. Surface format broadcast without an automatic means of on-the-ground determination~~

	~~ADS-B Emitter Category set "A"~~					
~~Coding~~	*~~Meaning~~*	*~~Ground Speed~~*		*~~Airspeed~~*		*~~Radio Altitude~~*
~~0~~	~~No ADS-B emitter category information~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~1~~	~~Light (<15 500 lbs or 7 031 kg)~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~2~~	~~Small (15 500 to 75 000 lbs or 7 031 to 34 019 kg)~~	~~< 100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
~~3~~	~~Large (75 000 lbs to 300 000 lbs or 34 019 to 136 078 kg)~~	~~<100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
~~4~~	~~High-vortex aircraft~~	~~<100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
~~5~~	~~Heavy (> 300 000 lbs or 136 078 kg)~~	~~<100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
~~6~~	~~High performance~~ ~~(>5g acceleration and >400 knots)~~	~~<100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
~~7~~	~~Rotorcraft~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
	~~ADS-B Emitter Category Set "B"~~					
~~Coding~~	*~~Meaning~~*	*~~Ground Speed~~*		*~~Airspeed~~*		*~~Radio Altitude~~*
~~0~~	~~No ADS-B emitter category information~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~1~~	~~Glider/sailplane~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~2~~	~~Lighter-than-air~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~3~~	~~Parachutist/skydiver~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~4~~	~~Ultra-light/hang-glider/paraglider~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~5~~	~~Reserved~~	~~Reserved~~				
~~6~~	~~Unmanned aerial vehicle~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~7~~	~~Space/trans-atmospheric vehicle~~	~~<100 knots~~	~~And~~	~~<100 knots~~	~~and~~	~~<50 feet~~
	~~ADS-B Emitter Category Set "C"~~					
~~Coding~~	*~~Meaning~~*					
~~0~~	~~No ADS-B emitter category information~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~1~~	~~Surface vehicle – emergency vehicle~~	~~Always report surface position message (3.1.2.8.6.3.2)~~				
~~2~~	~~Surface vehicle - service vehicle~~	~~Always report surface position message (3.1.2.8.6.3.2)~~				
~~3~~	~~Fixed ground or tethered obstruction~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~				
~~4 – 7~~	~~Reserved~~	~~Reserved~~				
	~~ADS-B Emitter Category Set "D"~~					

~~*ADS-B Emitter Category set "A"*~~				
~~*Coding*~~	~~*Meaning*~~	~~*Ground Speed*~~	~~*Airspeed*~~	~~*Radio Altitude*~~
~~*Coding*~~	~~*Meaning*~~			
~~0~~	~~No ADS-B emitter category information~~	~~Always report airborne position message (3.1.2.8.6.3.1)~~		
~~1 – 7~~	~~Reserved~~	~~Reserved~~		

Origin: SP/5	**Rationale:** The deletion of the table 3-7 is proposed, after making explicit in 3.1.2.8.6.7 the requirements implied by reference to the table from 3.1.2.8.6.7 and changing all references to 'emitter category' to point to Doc 9871.

…

Table 3-9. Timer characteristics

Timer Name	*Number*	*Reference*	*Symbol*	*Duration s*	*Tolerance s*	*Resettable*
Non-selective lock-out	1	3.1.2.6.9.2	T_D	18	±1	no
Temporary alert	1	3.1.2.6.10.1.1.2	T_C	18	±1	no
SPI	1	3.1.2.6.10.1.3	T_I	18	±1	no
Reservations B, C, D	3*	3.1.2.6.11.3.1	T_R	18	±1	yes
Multisite lockout	78	3.1.2.6.9.1	T_L	18	±1	no
Basic dataflash	1	3.1.2.6.10.3.4.2	T_F	30	±1	no

* As required

…

Table 3-11. Transmitted interrogation signal details ~~tolerances~~

~~*Reference*~~	~~*Function*~~	~~*Tolerance*~~
~~3.1.2.1.4.1~~	~~Pulse duration P_1, P_2, P_3, P_4, P_5~~ ~~Pulse duration P_6~~	~~±0.09 microsecond~~ ~~±0.20 microsecond~~
~~3.1.1.4~~	~~Pulse duration P_1 – P_3~~ ~~Pulse duration P_1 – P_2~~	~~±0.18 microsecond~~ ~~±0.10 microsecond~~
~~3.1.2.1.5.1.3~~	~~Pulse duration P_3 – P_4~~	~~±0.04 microsecond~~
~~3.1.2.1.5.2.4~~	~~Pulse duration P_1 – P_2~~ ~~Pulse duration P_2 – sync phase reversal~~ ~~Pulse duration P_6 – sync phase reversal~~ ~~Pulse duration P_5 – sync phase reversal~~	~~±0.04 microsecond~~ ~~±0.04 microsecond~~ ~~±0.04 microsecond~~ ~~±0.05 microsecond~~
~~3.1.1.5~~	~~Pulse amplitude P_3~~	~~P_1 ±0.5 dB~~
~~3.1.2.1.5.1.4~~	~~Pulse amplitude P_4~~	~~P_3 ±0.5 dB~~
~~3.1.2.1.5.2.5~~	~~Pulse amplitude P_6~~	~~Equal to or greater than P_2 – 0.25 dB~~

~~3.1.2.1.4.1~~	~~Pulse rise times~~	~~0.05 microsecond minimum,~~ ~~0.1 microsecond maximum~~
~~3.1.2.1.4.1~~	~~Pulse decay times~~	~~0.05 microsecond minimum,~~ ~~0.2 microsecond maximum~~

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Function	*Value*	*Reference*
	Mode A/C	
Carrier frequency	1030 ±0.20 MHz	3.1.1.1.1 – 3.1.1.1.2
Pulse interval P_1 – P_3 (Mode A)	8 ±0.18 microsecond	3.1.1.4.3
Pulse interval P_1 – P_3 (Mode C)	21 ±0.18 microsecond	3.1.1.4.3
Pulse interval P_1 – P_2	2 ±0.10 microsecond	3.1.1.4.4
Pulse duration P_1, P_2, P_3	0.8 ±0.09 microsecond	3.1.1.4.5
Pulse rise times	0.05 microsecond minimum, 0.10 microsecond maximum	3.1.1.4.6
Pulse decay times	0.05 microsecond minimum, 0.20 microsecond maximum	3.1.1.4.7
Pulse amplitude P_3	P_1 ±0.5 dB	3.1.1.5.2
	Intermode	
Carrier frequency	1030 ±0.01 MHz	3.1.2.1.1
Pulse duration P_1, P_2, P_3, P_4	0.8 ±0.09 microsecond	3.1.2.1.4.1
Pulse rise times	0.05 microsecond minimum, 0.10 microsecond maximum	3.1.2.1.4.1
Pulse decay times	0.05 microsecond minimum, 0.20 microsecond maximum	3.1.2.1.4.1
Pulse interval P_1 – P_3 (Mode A-Only All-Call)	8 ±0.18 microsecond	3.1.2.1.5.1.2.1
Pulse interval P_1 – P_3 (Mode C-Only All-Call)	21 ±0.18 microsecond	3.1.2.1.5.1.2.1
Pulse interval P_1 – P_2	2 ±0.04 microsecond	3.1.2.1.5.1.2.1
Pulse interval P_3 – P_4	2 ±0.04 microsecond	3.1.2.1.5.1.2.1
Pulse amplitude P_3	P_1 ±0.5 dB	3.1.2.1.5.1.2.2
Pulse amplitude P_4	P_3 -0.5 dB/+2.5 dB	3.1.2.1.5.1.2.2
	Mode S	

Function	*Value*	*Reference*
Carrier frequency	1030 ±0.01 MHz	3.1.2.1.1
Pulse duration P_1, P_2, P_3, P_5	0.8 ±0.09 microsecond	3.1.2.1.4.1
Pulse duration P_6 (short)	16.25 ±0.20 microsecond	3.1.2.1.4.1
Pulse duration P_6 (long)	30.25 ±0.20 microsecond	3.1.2.1.4.1
Pulse rise times	0.05 microsecond minimum, 0.10 microsecond maximum	3.1.2.1.4.1
Pulse decay times	0.05 microsecond minimum, 0.20 microsecond maximum	3.1.2.1.4.1
Pulse interval $P_1 – P_2$	2 ±0.04 microsecond	3.1.2.1.5.2.4
Pulse interval P_2 — sync phase reversal	2.75 ±0.04 microsecond	3.1.2.1.5.2.4
Pulse interval P_6 — sync phase reversal	1.25 ±0.04 microsecond	3.1.2.1.5.2.4
Pulse interval P_5 — sync phase reversal	0.4 ±0.04 microsecond	3.1.2.1.5.2.4
Pulse amplitude P_2	Equal to or greater than P_1 – 0.25 dB	3.1.2.1.5.2.5
Pulse amplitude first microsecond P_6	Equal to or greater than P_1 – 0.25 dB	3.1.2.1.5.2.5

Origin:	**Rationale:**
SP/5	Table 3-9 and Table 3-11 are proposed to be amendment in order to reflect provisions on basic dataflash protocol and P4 amplitude tolerance (interrogation). ASWG TSG WP 17-07.0R2 Additional modifications (replacement of the table 3-11) are propose. Corrected pulse duration values and intermode P1 – P2 timing and updated references.

…

FIGURES FOR CHAPTER 3

…

Format No.	UF								
0	00000	3	RL:1	4	AQ:1	DS:8	10	AP:24	.... Short air-air surveillance (ACAS)
1	00001	27 or 83						AP:24	… Reserved
2	00010	27 or 83						AP:24	… Reserved
3	00011	27 or 83						AP:24	… Reserved
4	00100	PC:3	RR:5	DI:3	SD:16			AP:24	.... Surveillance, altitude request
5	00101	PC:3	RR:5	DI:3	SD:16			AP:24	.... Surveillance, identify request
6	00110	27 or 83						AP:24	… Reserved
7	00111	27 or 83						AP:24	… Reserved
8	01000	27 or 83						AP:24	… Reserved
9	01001	27 or 83						AP:24	… Reserved
10	01010	27 or 83						AP:24	… Reserved
11	01011	PR:4	IC:4	CL:3	16			AP:24	.... Mode S only all-call
12	01100	27 or 83						AP:24	… Reserved
13	01101	27 or 83						AP:24	… Reserved
14	01110	27 or 83						AP:24	… Reserved
15	01111	27 or 83						AP:24	… Reserved
16	10000	3	RL:1	4	AQ:1	18	MU:56	AP:24	.... Long air-air surveillance (ACAS)
17	10001	27 or 83						AP:24	… Reserved
18	10010	27 or 83						AP:24	… Reserved
19	10011	~~27 or 83~~107						~~AP:24~~	… Reserved for military use
20	10100	PC:3	RR:5	DI:3	SD:16	MA:56		AP:24	.... Comm-A, altitude request
21	10101	PC:3	RR:5	DI:3	SD:16	MA:56		AP:24	.... Comm-A, identify request
22	10110	27 or 83						AP:24	… Reserved for military use
23	10111	27 or 83						AP:24	… Reserved
24	11	RC:2	NC:4	MC:80				AP:24	.... Comm-C (ELM)

NOTES:

1. XX:M denotes a field designated "XX" which is assigned M bits.
2. N denotes unassigned coding space with N available bits. These shall be coded as ZEROs for transmission.
3. For uplink formats (UF) 0 to 23 the format number corresponds to the binary code in the first five 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 presently defined remain undefined in length. Depending on future assignment they may be short (56 bits) or long (112 bits) formats. Specific formats associated with Mode S capability levels are described in later paragraphs.
5. The PC, RR, DI and SD fields do not apply to a Comm-A broadcast interrogation.

Figure 3-7. Summary of Mode S interrogation or uplink formats

Format No.	DF										
0	00000	VS:1	CC:1	1	SL:3	2	RI:4	2	AC:13	AP:24	.... Short air-air surveillance (ACAS)
1	00001	27 or 83								P:24	… Reserved
2	00010	27 or 83								P:24	… Reserved
3	00011	27 or 83								P:24	… Reserved
4	00100	FS:3	DR:5	UM:6	AC:13					AP:24	.... Surveillance, altitude reply
5	00101	FS:3	DR:5	UM:6	ID:13					AP:24	.... Surveillance, identify reply
6	00110	27 or 83								P:24	… Reserved
7	00111	27 or 83								P:24	… Reserved
8	01000	27 or 83								P:24	… Reserved
9	01001	27 or 83								P:24	… Reserved
10	01010	27 or 83								P:24	… Reserved
11	01011	CA:3	AA:24							PI:24	.... All-call reply
12	01100	27 or 83								P:24	… Reserved
13	01101	27 or 83								P:24	… Reserved
14	01110	27 or 83								P:24	… Reserved
15	01111	27 or 83								P:24	… Reserved
16	10000	VS:1	2	SL:3	2	RI:4	2	AC:13	MV:56	AP:24	.... Long air-air surveillance (ACAS)
17	10001	CA:3	AA:24	ME:56						PI:24	… Extended squitter
18	10010	CF:3	AA:24	ME:56						PI:24	... Extended squitter/non transponder
19	10011	AF:3	104								... Reserved for ~~M~~military use~~extended squitter~~
20	10100	FS:3	DR:5	UM:6	AC:13	MB:56				AP:24 DP:24	.... Comm-B, altitude reply .... (see *Note 5*)
21	10101	FS:3	DR:5	UM:6	ID:13	MB:56				AP:24 DP:24	.... Comm-B, identify reply .... (see *Note 5*)
22	10110	27 or 83								P:24	… Reserved for military use
23	10111	27 or 83								P:24	… Reserved
24	11	1	KE:1	ND:4	MD:80					AP:24	.... Comm-D (ELM)

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 unassigned coding space with N available bits. These shall be coded as ZEROs for transmission.

3. For downlink formats (DF) 0 to 23 the format number corresponds to the binary code in the first five bits of the reply. Format number 24 is defined as the format beginning with “11” in the first two bit positions while the following three bits may 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 presently defined remain undefined in length. Depending on future assignment they may be short (56 bits) or long (112 bits) formats. Specific formats associated with Mode S capability levels are described in later paragraphs.
5. The Data parity (DP) (3.1.2.3.2.1.5) is used if it has been commanded by the OVC (3.1.2.6.1.4.1.i) in accordance with paragraph 3.1.2.6.11.2.5.

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

Origin:	**Rationale:**
SP/5	The amendments (Figure 3-7 and Figure 3-8) proposes clarifications on the downlink format 19, which is reserved for military application.

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CHAPTER 5. MODE S EXTENDED SQUITTER

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5.1 MODE S EXTENDED SQUITTER TRANSMITTING SYSTEM CHARACTERISTICS

Note.— Many of the requirements associated with the transmission of Mode S extended squitter are included in Chapters 2 through 5 ~~and Chapter 3~~ for Mode S transponder and non-transponder devices using the message formats defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). The provisions presented within the following subsections are focused on requirements applicable to specific classes of airborne and ground transmitting systems that are supporting the applications of ADS-B and TIS-B.*

5.1.1 ADS-B out requirements

5.1.1.1 Aircraft, surface vehicles and fixed obstacles supporting an ADS-B capability shall incorporate the ADS-B message generation function and the ADS-B message exchange function (transmit) as depicted in Figure 5-1.

5.1.1.1.1 ADS-B transmissions from aircraft shall be in accordance with 3.1.2.8.6.3 for transponder-based systems or 3.1.2.8.7.3.2 for non-transponder-based systems ~~include position, aircraft identification and type, airborne velocity, periodic status and event driven messages including emergency/priority information~~.

5.1.1.1.2 **Recommendation.—** *Extended squitter transmitting equipment should use formats and protocols of the latest version available.*

Note 1.— The data formats and protocols for messages transferred via extended squitter are specified in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Note 2.— Some States and/or regions require extended squitter version 2 or later to be transmitted by specific dates.

5.1.1.2 *Extended squitter ADS-B transmission requirements.* Mode S extended squitter transmitting equipment shall be classified according to the unit's intended range capability and the set of parameters that it is capable of transmitting consistent with the following definition of general equipment classes and the specific equipment classes defined in Tables 5-1 and 5-2:

a) Class A extended squitter airborne systems support an interactive capability incorporating both an extended squitter transmission capability (i.e. ADS-B OUT) with a complementary extended squitter reception capability (i.e. ADS-B IN) in support of onboard ADS-B applications;

b) Class B extended squitter systems provide a transmission only (i.e. ADS-B OUT without an extended squitter reception capability) for use on aircraft, surface vehicles, or fixed obstructions; and

c) Class C extended squitter systems have only a reception capability and thus have no transmission requirements.

~~5.1.1.3 *Class A extended squitter system requirements.* Class A extended squitter airborne systems shall have transmitting and receiving subsystem characteristics of the same class (i.e. A0, A1, A2, or A3) as specified in 5.1.1.1 and 5.2.1.2.~~

~~*Note.— Class A transmitting and receiving subsystems of the same specific class (e.g. Class A2) are designed to complement each other with their functional and performance capabilities. The minimum air-to-air range that extended squitter transmitting and receiving systems of the same class are designed to support are:*~~

~~*a) A0-to-A0 nominal air-to-air range is 10 NM;*~~

~~*b) A1-to-A1 nominal air-to-air range is 20 NM;*~~

~~*c) A2-to-A2 nominal air-to-air range is 40 NM; and*~~

~~*d) A3-to-A3 nominal air-to-air range is 90 NM.*~~

~~*The above ranges are design objectives and the actual effective air-to-air range of the Class A extended squitter systems may be larger in some cases (e.g. in environments with low levels of 1 090 MHz fruit) and shorter in other cases (e.g. in environments with very high levels of 1 090 MHz fruit).*~~

~~5.1.1.4 CONTROL OF ADS-B OUT OPERATION~~

~~5.1.1.4.1 **Recommendation.**— *Protection against reception of corrupted data from the source providing the position should be satisfied by error detection on the data inputs and the appropriate maintenance of the installation.*~~

~~5.1.1.4.2 If an independent control of the ADS-B OUT function is provided, then the operational state of the ADS-B OUT function shall be indicated to the flight crew, at all times.~~

~~*Note.— There is no requirement for an independent control for the ADS-B OUT function.*~~

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5.1.3 ADS-B OUT requirements for surface vehicles

5.1.3.1 All surface vehicles supporting any versions of extended squitter ADS-B capability shall transmit extended squitter messages as per 5.1.1.2.

5.1.3.2 *Extended squitter version 2 or later required system performance.* The position source and equipment installed in surface vehicles to transmit extended squitter version 2 or later messages shall support the following performance characteristics:
…

5.1.3.2.4 The system design assurance parameter shall be equal to 1 or more, which defines the probability of a failure resulting in transmission of false or misleading information to be less than or equal to 1 × 10^{-3}.

Note 1.— These minimum performance requirements for extended squitter version 2 or later transmitted position data from surface vehicles are necessary to support aircraft-based alerting applications.

Note 2.— Guidance material for implementation of surface vehicle ADS-B systems is contained in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

Origin:	**Rationale:**
SP/5	The amendments to provisions through from 5.1.1 to 5.1.3 are proposed, which are relating to the ADS-B transmitting subsystem characteristics introduced with ADS-B version 3. Also amendment to 5.1.1.1.1 is proposed to reflect changes to the messages in ADS-B version 3. In addition, editorial corrections to the Note under 5.1 are proposed.

5.2 MODE S EXTENDED SQUITTER RECEIVING SYSTEM CHARACTERISTICS (ADS-B IN AND TIS-B IN)

Note 1.— The paragraphs herein describe the required capabilities for 1 090 MHz receivers used for the reception of Mode S extended squitter transmissions that convey ADS-B and/or TIS-B messages. Airborne receiving systems support ADS-B and TIS-B reception while ground receiving systems support only ADS-B reception.

Note 2.— Detailed technical provisions for Mode S extended squitter receivers can be found within RTCA DO-260C~~B~~/EUROCAE ED-102B~~A~~, "Minimum Operational Performance Standards for 1 090 MHz Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS B)."

…

5.2.2.4 *Enhanced reception techniques.* Class A1, A2 and A3 airborne receiving systems shall include the following features to provide improved probability of Mode S extended squitter reception in the presence of multiple overlapping Mode A/C fruit and/or in the presence of an overlapping stronger Mode S fruit, as compared to the performance of the standard reception technique required for Class A0 airborne receiving systems:

a) Improved Mode S extended squitter preamble detection.

…

d) Advanced range receiver techniques for Class A3 receivers which includes optional additional performance enhancements from the use of multiple receivers and antenna sectorization.

Note 1.— The above enhanced reception techniques are as defined in RTCA DO-260C~~B~~/EUROCAE ED-102B~~A~~, Appendix I.

Note 2.— The performance provided for each of the above enhanced reception techniques when used in a high fruit environment (i.e. with multiple overlapping Mode A/C fruit) is expected to be at least equivalent to that provided by the use of the techniques described in RTCA DO-260C~~B~~/EUROCAE ED-102B~~A~~, Appendix I.

…

5.2.3.2 When an extended squitter message is received, the message shall be decoded and the applicable ADS-B report(s) of the types defined in 5.2.3.3 shall be generated within 0.5 seconds.

..

Note 2.— Extended squitter ground receiving systems receive ADS-B messages and produce either application-specific subsets or complete ADS-B reports based on the needs of the ground service provider, including the client applications to be supported. Ground receiving systems may also generate ADS-B Wx Pilot reports (PIREPs) based upon ADS-B Wx PIREP messages. Additional information on the ADS-B Wx PIREP message can be found in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871).

Note 3.— The extended squitter message reception function may be physically partitioned into hardware separate from those that implement the report assembly function.

5.2.3.3 ADS-B REPORT TYPES

Note~~ 1~~.— The ADS-B report refers to the restructuring of ADS-B message data received from Mode S extended squitter broadcasts into various reports that can be used directly by a set of client applications. ~~Five~~Seven ADS-B report types are *defined by the following subparagraphs for output to client applications. Additional information on the ADS-B report contents and the applicable mapping from extended squitter messages to ADS-B reports can be found in ~~the~~* ~~Technical Provisions for Mode S Services and Extended Squitter~~ *~~(Doc 9871) and~~ RTCA DO-260C~~B~~ / EUROCAE ED-102B~~A~~.*

~~Note 2.— The use of precision (e.g. GNSS UTC measured time) versus non-precision (e.g. internal receiving system clock) time sources as the basis for the reported time of applicability is described in 5.2.3.5.~~

5.2.3.3.1 *State vector report.* The state vector report shall contain time of applicability, information about an airborne or vehicle's current kinematic state (e.g. position, velocity), as well as a measure of the integrity of the navigation data, based on information received in airborne or surface~~ground~~ position, airborne velocity, identification and category, and aircraft operational status ~~and target state and status~~ extended squitter messages. Since separate messages are used for position and velocity, the time of applicability shall be reported individually for the position related report parameters and the velocity related report parameters. Also, the state vector report shall include a time of applicability for the estimated position and/or estimated velocity information (i.e. not based on a message with updated position or velocity information) when such estimated position and/or velocity information is included in the state vector report.

…

5.2.3.3.2 *Mode status report.* The mode status report shall contain time of applicability and current operational information about the transmitting participant, including airborne/vehicle address, call sign, ADS-B version number, airborne/vehicle length and width information, state vector quality information, and other information based on information received in aircraft operational status, target state and status, aircraft identification and category, airborne velocity and aircraft status extended squitter messages. Each time that a mode status report is generated, the report assembler function shall update the report time of applicability. Parameters for which valid data is not available shall either be indicated as invalid or omitted from the mode status report.

Note 1.— Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne).

Note 2.— The age of the information being reported within the various data elements of a mode status report may vary as a result of the information having been received within different extended squitter messages at different times. In the absence of item specific timestamp information, the Mode status report includes an optional data update flag that provides applications with the means to establish data age.

5.2.3.3.3 *Air referenced velocity report.* Air referenced velocity reports shall be generated when air referenced velocity information is received in airborne velocity or ADS-B Wx AIREP extended squitter messages. The air referenced velocity report shall contain time of applicability, airspeed and heading information. Only certain classes of extended squitter receiving systems, as defined in 5.2.3.5, are required to generate air referenced velocity reports. Each time that an individual ~~mode status~~ air referenced velocity report is generated, the report assembly function shall update the report time of applicability.

Note 1.— The air referenced velocity report contains velocity information that is received in airborne velocity or ADS-B Wx AIREP messages along with additional information received in airborne identification and category extended squitter messages. Air referenced velocity reports are not generated for surface participants~~when ground referenced velocity information is being received in the airborne velocity extended squitter messages.~~

Note 2.— Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant ~~(ground or airborne)~~.

...

5.2.3.3.6 ADS-B Wx Air Report (AIREP)

Note.— The ADS-B Wx Air report is an optional report that will be generated when weather information is received in ADS-B Wx subtype 1 and 2 messages along with additional weather information received in Aircraft status subtype 1 extended squitter messages. The ADS-B Wx subtype 1 and 2 messages are defined in the Technical Provisions for Mode S Services and

Extended Squitter *(Doc 9871). Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant.*

5.2.3.3.7 Aircraft State Report

Note.— The aircraft state report is an optional report that will be generated when information is received in ADS-B Wx subtype 0 messages. The ADS-B Wx subtype 0 message is defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871). Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant (ground or airborne).*

…

5.2.3.4.1 As TIS-B messages are received by airborne receiving systems, the information shall be reported to client applications. Each time that an individual TIS-B report is generated, the report assembly function shall update the report time of applicability to the current time.

Note 1.— The TIS-B message formats are defined in the Technical Provisions for Mode S Services and Extended Squitter *(Doc 9871).*

…

~~*Note 3.— The use of precision (e.g. GNSS UTC measured time) versus non-precision (e.g. internal receiving system clock) time sources as the basis for the reported time of applicability is described in 5.2.3.5.*~~

5.2.3.4.2 *TIS-B target report.* All received information elements, other than position, shall be reported directly, including all reserved fields for the TIS-B fine format messages~~ and the entire message content of any received TIS-B management message~~. The reporting format is not specified in detail, except that the information content reported shall be the same as the information content received.

…

5.2.3.4.5 Traffic uplink ~~*TIS-B*~~ *management report.* The entire message content of any received traffic uplink~~TIS-B~~ management message shall be reported directly to the client applications. The information content reported shall be the same as the information content received.

5.2.3.4.5.1 The contents of any received traffic uplink~~TIS-B~~ management message shall be reported bit-for-bit to the client applications.

5.2.3.5 REPORT TIME OF APPLICABILITY

The receiving system shall use a local source of reference time as the basis for reporting the time of applicability, as defined for each specific ADS-B and TIS-B report type (see 5.2.3.3 and 5.2.3.4).

5.2.3.5.1 *GNSS UTC measure ~~Precision~~ time reference.* For r~~R~~eceiving systems that ~~intended to~~ generate ADS-B and/or TIS-B reports ~~based on the reception of surface position messages, airborne position messages, and/or TIS-B messages shall~~ that use GNSS UTC measured time for the purpose of generating the report time applicability, ~~for the following cases of received messages:~~

~~a) version zero (0) ADS-B messages, as defined in 3.1.2.8.6.2, when the navigation uncertainty category (NUC) is 8 or 9; or~~

~~b) version one (1) or version two (2) ADS-B or TIS-B messages, as defined in 3.1.2.8.6.2 and 3.1.2.8.7 respectively, when the navigation integrity category (NIC) is 10 or 11;~~

UTC measured time data shall have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

5.2.3.5.2 *Established installation receiver* ~~*NON-PRECISION LOCAL*~~ *TIME REFERENCE.*

5.2.3.5.2.1 ~~For receiving systems not intended to generate ADS-B and/or TIS-B reports based on reception of ADS-B or TIS-B messages meeting the NUC or NIC criteria as indicated in 5.2.3.5.1, a non-precision time source shall be allowed.~~ Receiving systems that generate ADS-B and/or TIS B reports that do not use GNSS UTC measure time per 5.2.3.5.1 and ~~In such cases, where~~ there is no appropriate ~~precision~~ time ~~source~~reference available, the receiving system shall establish an appropriate internal clock or counter having a maximum clock cycle or count time of 20 milliseconds. The established cycle or clock count shall have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

Note.— The use of a ~~non-precision~~ time reference as described above is intended to allow the report time of applicability to accurately reflect the time intervals applicable to reports within a sequence. For example the applicable time interval between state vector reports could be accurately determined by a client application, even though the absolute time ~~(e.g. UTC measured time)~~ would not be indicated by the report.

…

TABLES FOR CHAPTER 5

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Table 5-3. Reception performance for airborne receiving systems

Receiver class	*Intended air-to-air operational range*	*Receiver minimum trigger threshold level (MTL) (see* Note 1*)*	*Reception Technique (see* Note 2*)*	*Required extended squitter ADS-B message support (includes ADS-R and ADS-SLR)*	*Required extended squitter TIS-B message support (includes management messages)*
A0 (Basic VFR)	10 NM	–72 dBm	Standard	Airborne position Surface position Airborne velocity Aircraft identification and category ~~Extended squitter airborne~~ Aircraft status Aircraft operational status	Fine airborne position ~~Coarse airborne position~~ Fine surface position Aircraft identification and category Airborne velocity Management
A1 (Basic IFR)	20 NM	–79 dBm	Enhanced	Airborne position Surface position Airborne velocity Aircraft identification and category ~~Extended squitter airborne~~ Aircraft status Aircraft operational status	Fine airborne position ~~Coarse airborne position~~ Fine surface position Aircraft identification and category Airborne velocity Management
A2 (Enhanced IFR)	40 NM	–79 dBm	Enhanced	Airborne position Surface position Airborne velocity Aircraft identification and category ~~Extended squitter airborne~~ Aircraft status Aircraft operational status Target state and status	Fine airborne position ~~Coarse airborne position~~ Fine surface position Aircraft identification and category Airborne velocity Management
A3 (Extended capability)	90 NM	–84 dBm (and –87 dBm at 15% probability of reception)	Enhanced	Airborne position Surface position Airborne velocity Aircraft identification and category ~~Extended squitter airborne~~ Aircraft status Aircraft operational status Target state and status	Fine airborne position ~~Coarse airborne position~~ Fine surface position Aircraft identification and category Airborne velocity Management

Note 1.— Specific MTL is referenced to the signal level at the output terminal of the antenna, assuming a passive antenna. If electronic amplification is integrated into the antenna assembly, then the MTL is referenced at the input to the amplifier. For Class A3 receivers, a second performance level is defined at a received signal level of –87 dBm where 15 per cent of the messages are to be successfully received. MTL values refer to reception under non-interference conditions.

Note 2.— The extended squitter receiver reception techniques are defined in 5.2.2.4. "Standard" reception techniques refer to the baseline techniques, as required for ACAS 1 090 MHz receivers, that are intended to handle single overlapping Mode A/C fruit. "Enhanced" reception techniques refer to techniques intended to provide improved reception performance in the presence of multiple overlapping Mode A/C fruit and improved decoder re-triggering in the presence of overlapping stronger Mode S fruit. The requirements for the enhanced reception techniques that are applicable to the specific airborne receiver classes are defined in 5.2.2.4.

Note 3.— Management messages include TIS-B, ADS-R and ADS-SLR services. ADS-Rebroadcast (ADS-R) and ADS-Same Link Rebroadcast (ADS-SLR) are defined in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871).

Table 5-4. Mode S extended squitter airborne receiving system reporting requirements

Receiver class	*Minimum ADS-B reporting requirements*	*Minimum TIS-B reporting requirements*
A0 (Basic VFR)	ADS-B state vector report (per 5.2.3.3.1) and ADS-B mode status report (per 5.2.3.3.2)	TIS-B state report and ~~TIS-B~~Traffic uplink management report
A1 (Basic IFR)	ADS-B state vector report (per 5.2.3.3.1) and ADS-B mode status report (per 5.2.3.3.2) and ADS-B air referenced velocity report (ARV) (per 5.2.3.3.3)	TIS-B state report and ~~TIS-B~~ Traffic uplink management report
A2 (Enhanced IFR)	ADS-B state vector report (per 5.2.3.3.1) and ADS-B mode status report (per 5.2.3.3.2) and ADS-B ARV report (per 5.2.3.3.3) and ADS-B target state report (per 5.2.3.3.5)	TIS-B state report and ~~TIS-B~~Traffic uplink management report
A3 (Extended capability)	ADS-B state vector report (per 5.2.3.3.1) and ADS-B mode status report (per 5.2.3.3.2) and ADS-B ARV report (per 5.2.3.3.3) and ADS-B target state report (per 5.2.3.3.5)	TIS-B state report and ~~TIS-B~~ Traffic uplink management report

Note.— Traffic uplink management reports include TIS-B, ADS-R and ADS-SLR service status.

Origin:	**Rationale:**
SP/5	The amendments to provisions through from 5.2 to table 5-4 are proposed, which are relating to the ADS-B receiving subsystem characteristics introduced with version 3. ADS-B version 3 supports the broadcast of aircraft-based weather data. The same transponder makes that data available for extraction by Mode S radars. Such data support next generation applications such as IM, wake vortex avoidance and surfing, hazardous weather detection and avoidance, and aviation weather forecasting. Weather data requirements were derived from RTCA DO-364 Minimum Aviation System Performance Standards (MASPS) for Aeronautical Information/Meteorological Data Link Services, which built on previous work from RTCA, World Meteorological Organization, and ICAO Annex 3. To support European airspace data requirements, ADS-B version 3 requires transmission of weather messages that enable the Ground to determine aircraft airspeed and heading for aircraft that support EHS. Also this includes proposals for ensuring consistent application of terminology.

…

CHAPTER 6. MULTILATERATION SYSTEMS

6.1 INTRODUCTION

Note 1.— Multilateration (MLAT) systems use the time difference of arrival (TDOA) of the transmissions of an SSR transponder (or the extended squitter transmissions of a non-transponder device) between several ground receivers to determine the position of the aircraft (or ground vehicle). A multilateration system can be:

…

~~6.1 DEFINITIONS~~

~~***Multilateration (MLAT) System.*** A group of equipment configured to provide position derived from the secondary surveillance radar (SSR) transponder signals (replies or squitters) primarily using time difference of arrival (TDOA) techniques. Additional information, including identification, can be extracted from the received signals.~~

~~***Time Difference of Arrival (TDOA).*** The difference in relative time that a transponder signal from the same aircraft (or ground vehicle) is received at different receivers.~~

~~***Wide area multilateration (WAM) system.*** A multilateration system deployed to support en-route surveillance, terminal area surveillance and other applications such as height monitoring and precision runway monitoring (PRM).~~

Origin: SP/5	**Rationale:** All definitions are proposed to be grouped in Chapter 1 to improve readability and consistency with other ICAO documents.

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…

Airborne collision avoidance system (ACAS). An aircraft system based on ~~secondary~~ surveillance ~~radar (SSR) transponder signals~~ information ~~which operates independently of ground-based equipment~~ to provide alerting and manoeuvre guidance to ~~advice to the~~ pilots and/or automated flight systems to limit collision risk with other airborne ~~on potential conflicting~~ aircraft ~~that are equipped with SSR transponders~~.

~~*Note.— SSR transponders referred to above are those operating in Mode C or Mode S. ACAS may also use automatic dependent surveillance — broadcast (ADS-B) signals received from other aircraft to improve its performance*~~.

Origin: SP/5	**Rationale:** The definition is modified to accommodate ACAS III systems that use an air to air radar in addition to SSR surveillance and prepare for future systems that may also use ground-based surveillance and/or ground-based logic. It also states which kind of advice is provided and in which aim.

Traffic information service – broadcast (TIS-B) OUT. A function on the ground that periodically broadcasts the surveillance information of non-ADS-B Out equipped aircraft/vehicles or aircraft/vehicles that have lost or degraded ADS-B Out capability made available by ground sensors in a format suitable for TIS-B IN capable receivers.

~~*Note.— This technique can be achieved through different data links. The requirements for Mode S extended squitters are specified in Annex 10, Volume IV, Chapter 5. The requirements for VHF digital link (VDL) Mode 4 and universal access transceiver (UAT) are specified in Annex 10, Volume III, Part I.*~~

…

Origin: SP/5	**Rationale:** The amendment to definition of TIS-B Out is proposed for ensuring consistent application of terminology and reflects how industry implements TIS-B.

CHAPTER 4. AIRBORNE COLLISION AVOIDANCE SYSTEM

INTRODUCTION

~~Introductory Note.—~~ This chapter contains SARPs on ACAS I, ACAS II and ACAS III. The focus is especially on ACAS II and ACAS III. ~~which provides vertical resolution advisories (RAs) in addition to traffic advisories (TAs), and the related provisions are detailed in the following sections:~~

~~4.3 GENERAL PROVISIONS RELATING TO ACAS II AND ACAS III~~
~~4.4 PERFORMANCE OF THE ACAS II COLLISION AVOIDANCE LOGIC and~~
~~4.5 ACAS USE OF EXTENDED SQUITTER~~

Rationale

All the section except 4.1 now apply to both ACAS II and ACAS III.

~~ACAS X~~ACAS Xa/Xo and TCAS Version 7.1 are considered ~~as~~ ACAS II systems. The provisions for ~~ACAS X~~ACAS Xa/Xo compliant systems in this chapter cover ACAS Xa (a stands for active surveillance, which is its main surveillance source) and ACAS Xo (o stands for operation specific). ACAS Xa is developed for large commercial aircraft. ACAS Xo is a specific variation of ~~ACAS X~~ACAS Xa/Xo that adds special modes to ACAS Xa.

~~ACAS X~~ACAS Xa/Xo is an alternative to, and interoperable with, TCAS Version 7.1 compliant systems. However there are differences between ~~ACAS X~~ACAS Xa/Xo and TCAS Version 7.1, mainly in two areas: the collision avoidance logic and the sources of surveillance data. With these differences, technical requirements which are specific to either ~~ACAS X~~ACAS Xa/Xo or TCAS version 7.1 are identified within this Annex as "For ~~ACAS X~~ACAS Xa/Xo compliant systems" or "For TCAS 7.1 compliant systems".

Rationale

The previous change to Annex 10 Volume 4 used ACAS X for ACAS Xa/Xo which was at the time the only standardized variant of the ACAS X family. With the standardization of ACAS Xu it becomes necessary to indicate when ACAS X means only ACAS Xa/Xo instead of all standardized ACAS X.

ACAS Xu (u stands for unmanned) is considered an ACAS III system. ACAS Xu is interoperable with ACAS X and TCAS version 7.1 compliant systems.

Rationale

ACAS Xu collision avoidance functionality is the basis for the ACAS III requirements, so this system is de facto an ACAS III system. The interoperability has been demonstrated.

Guidance material related to both ACAS X compliant systems and TCAS 7.1 compliant systems including similarities and differences (e.g. monitoring and training) are contained in the Airborne Collision Avoidance System (ACAS) Manual (Doc 9863).

It is to be noted that hybrid and extended hybrid surveillance provisions contained in section 4.5 describe functionalities which are optional for TCAS version 7.1 compliant systems. However, their use is encouraged in order to minimize the risk of ACAS RF spectrum congestion, as proper and efficient utilization of available bandwidth and capacity at 1030 MHz and 1090 MHz is a key element to ensure the safe operation of not only ACAS but also several surveillance systems such as secondary surveillance radar (SSR) and automatic dependent surveillance broadcast (ADS-B). These functionalities are included in ~~ACAS X~~ACAS Xa/Xo and ACAS Xu compliant systems.

~~*Non-SI alternative units are used as permitted by Annex 5, Chapter 3, 3.2.2. In limited cases, to ensure consistency at the level of the logic calculations, units such as ft/s, NM/s and kt/s are used.*~~

Rationale

The paragraph is moved to the end of the introduction, as it is a more logical place for it.

For more details of TCAS Version 7.1 compliant systems, refer to the RTCA/DO-185B or EUROCAE/ED-143 specifications, i.e. equipment that incorporates the traffic alert and collision avoidance systems (TCAS) Version 7.1. For ~~ACAS X~~ACAS Xa/Xo compliant systems, refer to the RTCA/DO-385 or EUROCAE/ED-256 specifications, i.e. equipment that incorporates the airborne collision avoidance system Xa/Xo (~~ACAS X~~ACAS Xa/Xo). Equipment meeting the ~~ACAS X~~ACAS Xa/Xo or TCAS Version 7.1 specifications listed above are compliant with the ACAS II requirements listed in Chapter 4. Equipment meeting the RTCA/DO-185A specifications (also known as TCAS Version 7.0) are not compliant with the ACAS II requirements listed in Chapter 4.

For more details of ACAS Xu compliant systems, refer to the RTCA/DO-386 or EUROCAE/ED-275 specifications. i.e. equipment that incorporates the airborne collision avoidance system Xu (ACAS Xu). Equipment meeting the ACAS Xu specifications listed above are compliant with the ACAS III requirements listed in Chapter 4.

Rationale

In the same way as ACAS II existing industry standards (TCAS v7.1 and ACAS Xa/Xo) are referred to above, a reference is made to the ACAS III existing industry standards.

Non-SI alternative units are used as permitted by Annex 5, Chapter 3, 3.2.2. In limited cases, to ensure consistency at the level of the logic calculations, units such as ft/s, NM/s and kt/s are used.

Rationale

The paragraph is moved to the end of the introduction, as it is a more logical place for it.

4.1 DEFINITIONS RELATING TO AIRBORNE COLLISION AVOIDANCE SYSTEM

4.1.1 Definitions common with Annex 10 Volume IV Part 2

Rationale

The following definitions have been developed in collaboration with RPASP/WG3 and will be common between Part 1 and Part 2.

Caution level alert. An alert that requires immediate pilot awareness and subsequent pilot response.

Rationale

Detect And Avoid (DAA) systems (described in Part 2) and ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

Collision Avoidance (CA) function. A function used to provide alerts to indicate the need to take immediate action by generating a recommended manoeuvre to limit the risk of collision with all threats.

Rationale

DAA systems include a Remain Well Clear function and a Collision Avoidance function. The definition of the latter is needed because it is used in the PfA.

Collision avoidance system (CAS). A system that implements a collision avoidance function.

Origin: SP/5	**Rationale:** A definition of CAS is introduced, which is broader than the current ACAS definition. CAS can be used to cover potential non-ICAO compliant collision avoidance systems. It is used in the meaning of the values of a communication sub-field.

Cooperative aircraft. Aircraft that transmit surveillance data that can be received by own aircraft.

Rationale

The definition supports the surveillance and the performance provisions which now address the optional use of a sensor to detect non-cooperative aircraft.

Coordination. The process of ensuring that the collision avoidance system or function ~~by which~~on any two ~~ACAS-equipped~~conflicting aircraft select compatible resolution advisories (RAs). ~~*by the exchange of resolution advisory complements (RACs).*~~

Note. — ACAS selects compatible resolution advisories (RAs) by the exchange of resolution advisory complements (RACs).

Rationale

The definition has to be broadened to include the collision function of DAAs, allowing other schemes of coordination than the exchange of RACs.

DAA Well Clear (DWC). A temporal and/or spatial boundary around the aircraft intended to be used in a DAA system as an electronic means of avoiding conflicting traffic.

Rationale

The definition is needed because the terms are used in the definition of Remain Well Clear function

Encounter. For the purposes of defining the performance of the collision avoidance logic, an encounter consists of two simulated aircraft trajectories.

Rationale

The definition has been relocated from section 4.4 as it can be used for the validation of the collision avoidance function of DAA systems as well.

Field of regard (FOR): The total area at any given range that a sensor can perceive with adequate resolution. The field of regard is typically much larger than the sensor's field of view. For a stationary sensor that is not scanning, the field of regard and field of view coincide.

Field of view: The total area at any given range that a sensor can perceive with adequate resolution at a single point in time.

Rationale

The definitions support the surveillance provisions which now address the optional use of a sensor to detect non-cooperative aircraft.

Interoperability. The capability to operate in airspace with other collision avoidance systems or DAA systems without negatively impacting the other systems or the safe and orderly flow of air traffic.

Rationale

The definition supports the performance provisions which refer to the interoperability MASPS for collision avoidance systems (EUROCAE ED-264 / RTCA DO-382).

Intruder. An aircraft within the surveillance volume for which ~~ACAS has an established track~~ a track has been established.

Rationale

The intruder definition has to be broadened to apply to DAA tracked aircraft.

Near midair collision (NMAC). Two aircraft simultaneously coming within 30 meters (100 ft.) vertically and 150 meters (500 ft.) horizontally.

Note. —Reference is made to RTCA DO-185B/EUROCAE ED-143

Near threat. An intruder deserving special attention because it is close to becoming a potential threat, based on separate tests on measurements meeting specific criteria.

Non-cooperative aircraft. Aircraft that do not transmit surveillance data that can be received by own aircraft.

Note. — This may be due to the lack of such equipment, or such equipment not operating due to malfunction or deliberate action.

Rationale
The definition supports the surveillance and performance provisions which now address the optional use of a sensor to detect non-cooperative aircraft.

Potential threat. An intruder deserving special attention either because of its close proximity to own aircraft or because successive ~~range and altitude~~ measurements indicate that it could be on a collision or near-collision course with own aircraft. The ~~warning~~ alerting time provided against a potential threat is sufficiently small that a ~~traffic advisory (TA)~~ caution level alert is justified but not so small that a resolution advisory (RA) would be justified.

Note. — A Traffic Advisory (TA) is considered a caution level alert.

Rationale
The measured parameters are no longer specified to allow other input parameters than those of active transponder surveillance (e.g. ADS-B).
Detect And Avoid (DAA) systems (described in Part 2) and ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

Resolution advisory (RA). ~~An indication~~ A combination of alerting and guidance given to the flight crew recommending:

a) ~~a manoeuvre intended to provide separation from all threats~~ a vertical and/or horizontal manoeuvre intended to mitigate a collision hazard from all current threats; or

b) ~~a manoeuvre restriction intended to maintain existing separation~~ a vertical and/or horizontal manoeuvre restriction intended to limit the risk of collision.

Rationale
The definition requires a change to make it more generic for DAA and to avoid the use of the controversial word "separation". The proposed definition uses wording from the proposed definition for collision avoidance function.

Remain-Well-Clear (RWC) function. A function used to alert the pilot of the need to take action, as approved by ATC if receiving separation services, by generating one or more recommended manoeuvres to mitigate a Potential Threat by passing DAA Well Clear.

Rationale
DAA systems include a Remain Well Clear function and a Collision Avoidance function. The definition of the former is needed because it is used in the text of the PfA.

Threat. An intruder ~~deserving~~ whose position is independently tracked or subject to a validation function and that requires special attention, either because of its close proximity to own aircraft or because successive ~~range and altitude~~ measurements indicate that it ~~could be~~ is on a collision or near-collision course with own aircraft. The warning time provided against a threat is sufficiently small that ~~an RA~~ a Resolution Advisory is justified using warning-level alerting.

Note.— Mode-S interrogations/replies, primary surveillance radar, electro-optical sensors are all considered independent means of tracking threats. Reference is made to part 2 § 3.2.1.2.1.4, § 3.2.1.2.2.3 and § 3.2.1.2.3.3 for validation of ADS-B data.

Rationale
The need for the position to be independently tracked or validated is now included as an intruder can now (eg in ACAS Xa and Xu) be declared a threat using passive surveillance.
The measured parameters are no longer specified to allow other input parameters than those of active transponder surveillance (e.g. ADS-B).
Warning-level alerting is mentioned as the level of alert that an RA corresponds to in the scheme described in FAA AC 25.1322 and EASA AMC 25.1322.

4.1.2 Definitions specific to Annex 10 Volume IV Part 1

ACAS I. An ACAS which provides information as an aid to “see and avoid” action but does not include the capability for generating resolution advisories (RAs).

Note.— ACAS I is not intended for international implementation and standardization by ICAO. Therefore, only ACAS I characteristics required to ensure compatible operation with other ACAS configurations and interference limiting are defined in 4.2.

ACAS II. An ACAS which provides vertical resolution advisories (RAs) in addition to caution level alerting in the form of traffic advisories (TAs).

ACAS III. An ACAS which provides vertical and horizontal resolution advisories (RAs) in addition to ~~traffic advisories (TAs)~~ caution level alerting.

Rationale

Detect And Avoid (DAA) systems (described in Part 2) and ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

…

Active CAS. A collision avoidance system that uses 1030/1090 MHz interrogation/reply messages for maneuver coordination.

...

Climb RA. A positive RA ~~recommending~~ that advises a climb but not an increased climb.

…

Coordination interrogation. A Mode S interrogation (uplink transmission) radiated by ACAS II or III and containing a resolution message. [Note for the editor: Missing blank line below]

Coordination reply. A Mode S reply (downlink transmission) acknowledging the receipt of a coordination interrogation by the Mode S transponder that is part of an ACAS II or III installation.

...

Descend RA. A positive RA ~~recommending~~ that advises a descent but not an increased descent.

…

Increased rate RA. A resolution advisory with a strength that ~~recommends~~ advises increasing the altitude rate to a value exceeding that ~~recommended~~ advised by a previous climb or descend RA.

…

Operational Coordination Message (OCM). An ADS-B message that contains the same pairwise RA complements as TCAS Resolution Messages.

Rationale

The definition relates to the mechanism used for passive coordination of ACAS RAs, allowed by ACAS Xa compliant systems and ACAS III systems.

Own aircraft. The ACAS-equipped reference aircraft ~~fitted with the ACAS that is the subject of the discourse, which ACAS is to protect against possible collisions, and which may enter a manoeuvre in response to an ACAS indication~~.

Positive RA. A resolution advisory that advises ~~the pilot either to~~ a climb, ~~or to descend~~ descent and/or turn ~~(applies to ACAS II)~~.

Passive CAS. A collision avoidance system that uses broadcast messages (e.g. ADS-B) for maneuver coordination.

...

Radar Closest Performance Range (RCPR). Maximum value for the minimum range at which the track accuracy requirements for a radar-generated track need to be met.

Radar Declaration Range (RDR). Minimum value for the maximum range at which the track accuracy requirements for a radar-generated track need to be met.

Rationale

The definitions support the surveillance provisions which now address the optional use of a sensor to detect non-cooperative aircraft.

RA sense. The sense of an ACAS ~~II~~ vertical RA is “upward” if it requires climb or limitation of descent rate and “downward” if it requires descent or limitation of climb rate. It can be both upward and downward simultaneously if it requires limitation of the vertical rate to a specified range.

Note.— The RA sense may be both upward and downward when, having several simultaneous threats, ACAS generates an RA aimed at ensuring adequate ~~separation~~ vertical distance below some threat(s) and above some other threat(s)

....

Sensitivity level (S). An integer defining a set of parameters used by ~~the~~ some traffic advisory (TA) and collision avoidance algorithms to control the warning time provided by the potential threat and threat detection logic, as well as the values of parameters relevant to the RA selection logic.

…

Note.— For TA and RA selection, sensitivity level is not used in ACAS X compliant systems.

Track. A sequence of measurements representing positions that could reasonably have been occupied by an aircraft.

Traffic advisory (TA). ~~An indication~~ A caution-level alert given to the flight crew indicating that a certain intruder is a potential threat.

Rationale

Detect And Avoid (DAA) systems (described in Part 2) and ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

Validation. The process of verifying the position of an intruder obtained from passive surveillance by comparing it to an independent surveillance source.

Note. — For example, the information obtained via ADS-B can be validated by comparing it to the relative position obtained via ACAS active interrogation, via primary surveillance radar or via EO/IR sensor.

Rationale

The validation function is mentioned in the Threat definition. More details are needed to explain what it is, expanding from the mechanism which is used in hybrid surveillance.

...

4.3.1 Functional requirements

4.3.1.1 *ACAS functions.* ACAS shall perform the following functions:

a) surveillance;

b) ~~generation of TAs~~generation of caution level alerting (see 4.3.3);

…

Rationale

ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

4.3.2 Surveillance performance requirements

4.3.2.1 *General surveillance requirements.* ACAS shall interrogate SSR Mode A/C and Mode S transponders in other aircraft and detect the transponder replies. ACAS shall measure the range and relative bearing of responding aircraft. For ACAS X compliant systems, in addition to information from other sources described above, ACAS shall be able to receive other aircraft's ADS-B position, velocity and status information.

Note..— ACAS may also use airborne primary surveillance radar tracks and/or Electro-Optical /Infra-Red (EO/IR) sensor tracks to measure the position and velocity of non-cooperative aircraft.

(note to the editor: add the numbering for this paragraph and renumber the following paragraphs accordingly, and consider a possible title as the text of the paragraph used to be in 4.3.2.1 above) Using these measurements and information ~~conveyed by transponder replies~~, as described in 4.3.2.1~~, and for ACAS X compliant systems also by ADS-B messages~~, ACAS shall estimate the relative positions of each responding aircraft. ACAS shall include provisions for achieving such position determination in the presence of ground reflections, interference and variations in signal strength.

4.3.2.1.1 *SURVEILLANCE OF TRANSPONDER-EQUIPPED AIRCRAFT*

4.3.2.1.1.1 *Track establishment probability.* ACAS (or the surveillance function serving the ACAS) shall generate an established track, with at least a 0.90 probability that the track is established 30 s before closest approach, on aircraft equipped with transponders when all of the following conditions are satisfied:

…

4.3.2.1.1.1.1 ACAS shall continue to provide surveillance with no abrupt degradation in track establishment probability as any one of the condition bounds defined in 4.3.2.1.1.1 is exceeded.

4.3.2.1.1.1.2 ACAS shall not track Mode S aircraft that report that they are on the ground.

Note.— A Mode S aircraft may report that it is on the ground by coding in the capability (CA) field in a DF = 11 or DF = 17 transmission (Chapter 3, 3.1.2.5.2.2.1) or by coding in the vertical status (VS) field in a DF = 0 transmission (Chapter 3, 3.1.2.8.2.1). Alternatively, if the aircraft is under Mode S ground surveillance, ground status may be determined by monitoring the flight status (FS) field in downlink formats DF = 4, 5, 20 or 21 (Chapter 3, 3.1.2.6.5.1).

~~4.3.2.1.1.1.3 **Recommendation.**— *ACAS should achieve the required tracking performance when the average SSR Mode A/C asynchronous reply rate from transponders in the vicinity of the ACAS aircraft is 240 replies per second and when the peak interrogation rate received by the individual transponders under surveillance is 500 per second.*~~

~~*Note.— The peak interrogation rate mentioned above includes interrogations from all sources.*~~

Rationale

This recommendation is now outdated.

4.3.2.1.1.2 *False track probability.* The probability that an established Mode A/C track does not correspond in range and altitude, if reported, to an actual aircraft shall be less than 1.2 per cent. For an established Mode S track this probability shall be less than 0.1 per cent. These limits shall not be exceeded in any traffic environment.

4.3.2.1.1.3 *Range and bearing accuracy*

4.3.2.1.1.3.1 Range shall be measured with a resolution of 14.5 m (1/128 NM) or better.

4.3.2.1.1.3.2 **Recommendation.—** *The errors in the relative bearings of the estimated positions of intruders should not exceed 10 degrees rms.*

Note.— This accuracy in the relative bearing of intruders is practicable and sufficient as an aid to the visual acquisition of potential threats. In addition, such relative bearing information has been found useful in threat detection, where it can indicate that an intruder is a threat. However, this accuracy is not sufficient as a basis for horizontal RAs, nor is it sufficient for reliable predictions of horizontal miss distance.

4.3.2.1.2 SURVEILLANCE OF NON-COOPERATIVE AIRCRAFT

ACAS with an airborne primary surveillance radar shall comply with the requirements related to non-cooperative surveillance in part II 3.2.2.1 and to airborne primary surveillance radar in part II 3.2.2.2 in addition to the requirements in 4.3.2.1.2.

Note.— The provisions included in 4.3.2.1.2 support the alerting ranges of remain-well-clear in addition to collision avoidance under the design assumption that non-cooperative aircraft fly at true air speed (TAS) up to 170 kt and own aircraft flies at TAS up to 200 kt. A radar meeting with these provisions but supporting only collision avoidance may be demonstrated to be valid for higher speed aircraft, as the radar declaration range RDR) required in Section 4.3.2.1.2.1.2 is greater than needed for collision avoidance only. For more details about design assumptions of airborne primary surveillance radar, refer to RTCA DO-366A Minimum Operational Performance Standards for Air-to-Air Radar for Traffic Surveillance.

4.3.2.1.2.1 *Detection volume*

4.3.2.1.2.1.1 ACAS with an airborne primary surveillance radar shall exhibit an RCPR of 4,000 ft

4.3.2.1.2.1.2 ACAS with an airborne primary surveillance radar, with an own aircraft that is capable of a standard turn rate (3°/s), shall exhibit an RDR in clear air in the head-on direction of:

- 5.4 NM against an aircraft that flies at TAS up to 100 kt
- 6 NM against an aircraft that flies at TAS between 100 kt and 130 kt
- 6.7 NM against an aircraft that flies at TAS greater than 130 kt

4.3.2.1.2.1.3 Minimum RDR values when the traffic is not in the head-on direction and/or when the own aircraft is incapable of a standard turn rate and/or the radar is operating in rain conditions shall be derived from the values in 4.3.2.1.2.1.2 using suitable adjustments.

*Note.— Suitable adjustments can be found in RTCA DO-366A M*inimum Operational Performance Standards for Air-to-Air Radar for Traffic Surveillance.

4.3.2.1.2.2 *Track establishment*

4.3.2.1.2.2.1 ACAS with an airborne primary surveillance radar shall generate an established track before the RCPR more than 99 % of the time for targets entering the radar FOR at or before the RDR.

4.3.2.1.2.2.2 ACAS with an airborne primary surveillance radar shall prioritize all targets according to their threat level. Targets whose threat level is above a suitable threshold shall be treated as high-priority targets. ACAS with an airborne primary surveillance radar shall support the establishment of at least five simultaneous tracks for high-priority targets (high-priority tracks).

Note.— A prioritization scheme and a suitable threshold for high-priority targets can be found in the ACAS Manual and in RTCA DO-366A Minimum Operational Performance Standards for Air-to-Air Radar for Traffic Surveillance.

4.3.2.1.2.2.3 ACAS with an airborne primary surveillance radar shall generate an established track for at least 95 % of all high-priority targets within the FOR starting at the RDR.

4.3.2.1.2.2.4 ACAS with an airborne primary surveillance radar shall generate an established track for high-priority airborne targets, that meets the track accuracy described in 4.3.2.1.2.3 at least 90 % of the time.

4.3.2.1.2.3 *High-priority targets track accuracy*

4.3.2.1.2.3.1 The error in the range of the estimated positions of intruders within the FOR and between the RDR and RCPR shall not exceed 86 ft rms.

4.3.2.1.2.3.2 The error in the range rate of the estimated positions of intruders within the FOR and between the RDR and RCPR shall not exceed 14.9 ft/s rms.

4.3.2.1.2.3.3 The angular error in azimuth of the estimated positions of intruders within the FOR and between the RDR and RCPR shall not exceed 0.9 degrees rms.

4.3.2.1.2.3.4 The angular error in elevation of the estimated positions of intruders within the FOR and between the RDR and RCPR shall not exceed 0.9 degrees rms.

Rationale

ACAS Xu has the capability to use an airborne primary surveillance radar as an input to the CA logic. It is proposed to recognize this option in Annex 10 and to provide a standardization framework for it performance, based on the RTCA MOPS (DO-366A Minimum Operational Performance Standards for Air-to-Air Radar for Traffic Surveillance).

…

4.3.2.2.2.2.1 *Transmissions during RAs.* All air-to-air coordination interrogations and all RA Broadcast Interrogations shall be transmitted at full power and these interrogations shall be excluded from the summations of Mode S interrogations in the left-hand terms of inequalities (1) and (2) in 4.3.2.2.2.2 for the duration of the RA.

Rationale

RA Broadcast Interrogations over 1030 MHz are used for ground monitoring of RAs. The rationale for exempting these interrogations from the Interference Limiting equation, without limiting the requirement to specific systems, is that the manufacturers already do so by interpreting the existing ACAS MOPS in a certain way. The relevant requirement was ambiguous in those documents, so it was cleared up in the ACAS Xu MOPS such that those negligible contributors to spectrum would not count against the surveillance power of a transmitter during an RA.

…

4.3.3 ~~Traffic advisories (TAs)~~Caution level alerting

4.3.3.1 FOR ACAS II SYSTEMS AND ACAS III SYSTEMS PROVIDING TRAFFIC ADVISORIES (TAs)

4.3.3.1.1 *TA function.* ACAS shall provide TAs to alert the flight crew to potential threats. Such TAs shall be accompanied by an indication of the approximate relative position of potential threats to facilitate visual acquisition.

4.3.3.1.1.1 *Display of potential threats.* If potential threats are shown on a traffic display, they shall be displayed in amber or yellow.

Note 1.— These colours are generally considered suitable for indicating a cautionary condition.

Note 2.—Additional information assisting in the visual acquisition such as vertical trend and relative altitude may be displayed as well.

Note 3.— Traffic situational awareness is improved when tracks can be supplemented by display of heading information (e.g. as extracted from received ADS-B messages).

Rationale
ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

4.3.3.1.2 DISPLAY OF PROXIMATE TRAFFIC ~~DISPLAY~~

Rationale
Cosmetic change to avoid the confusion with the "display" as an equipement

4.3.3.1.2.1 **Recommendation.—** *While any RA and/or TA are displayed, proximate traffic within 11 km (6 NM) range and, if altitude reporting, ±370 m (1 200 ft) altitude should be displayed. This proximate traffic should be distinguished (e.g. by colour or symbol type) from threats and potential threats, which should be more prominently displayed.*

4.3.3.1.2.2 **Recommendation.—** *While any RA and/or TA are displayed, visual acquisition of the threats and/or potential threat should not be adversely affected by the display of proximate traffic or other data unrelated to collision avoidance.*

4.3.3.1.3 *TAs as RA precursors.* The criteria for TAs shall be such that they are satisfied before those for an RA.

Note. — Ideally, RAs would always be preceded by a TA but this is not always possible, e.g. the RA criteria might be already satisfied when a track is first established, or a sudden and sharp manoeuvre by the intruder could cause the TA lead time to be less than a cycle.

4.3.3.1.3.1 *TA ~~warning~~ alerting time.*

~~4.3.3.3.1.1 For TCAS Version 7.1 compliant systems, the nominal TA warning time for intruders reporting altitude shall not be greater than (T+20 s) where T is the nominal warning time for the generation of the resolution advisory.~~

~~4.3.3.3.1.2 For ACAS X compliant systems, t~~The TA alerting ~~warning~~ time shall be sufficient to allow the flight crew to take actions described in PANS-OPS, Volume III and prepare for a potential resolution advisory.

Note.— The nominal TA alerting ~~warning~~ time is 20 s or less before the generation of the resolution advisory.

4.3.3.2 FOR ACAS III SYSTEMS PROVIDING REMAIN-WELL-CLEAR ALERTS

ACAS III logics integrated in a DAA system shall issue caution-level alerts that meet the functional requirements in Part II, section 4.4

Note.— ACAS Xu is an example of such a system.

Rationale
Warning time was replaced by alerting time to avoid confusion as TA is a caution-level alert, not a warning-level alert. The requirement prescribing a minimum value of TA for ACAS X has been found to be generally applicable to all ACAS, so it is

placed first, with no condition on the system.

…

4.3.4.1.1 *Intruder characteristics.* As a minimum, the characteristics of an intruder that are used to identify a threat shall include:

a) tracked altitude;

b) tracked rate of change of altitude;

c) tracked slant range;

d) tracked rate of change of slant range; and

e) for TCAS Version 7.1 compliant systems: sensitivity level of intruder's ACAS, S_i.

~~For an intruder not equipped with ACAS II or ACAS III, S_i shall be set to 1.~~

…

4.3.4.2 *Sensitivity levels.* ACAS shall be capable of operating at any of a number of sensitivity levels. These shall include:

a) S = 1, a "standby" mode in which the interrogation of other aircraft and all advisories are inhibited;

b) S = 2, a ~~"TA only"~~ mode in which RAs are inhibited; ~~and~~

Note. — In this mode, ACAS III logics that are not integrated in a DAA system issue TAs. ACAS III logics that are integrated in a DAA system issue other types of caution-level alerts.

c) for TCAS Version 7.1 compliant systems: S = 3-7, further levels that enable the issue of RAs that provide the warning times indicated in Table 4-2 as well as TAs.; and

d) for ACAS X compliant systems: S = 3, either:
  - (ACAS II) a "TA/RA" mode in which RAs and TAs can be issued, or
  - (ACAS III) a mode in which RAs and caution level alerts can be issued.

Rationale

ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

Table 4-2

For TCAS Version 7.1 compliant systems:

Sensitivity level	*2*	*3*	*4*	*5*	*6*	*7*
Nominal warning time	no RAs	15s	20s	25s	30s	35s

Rationale

The table is moved from a place after the next section to this more relevant position, just after the section which refers to it.

4.3.4.3 *Selection of own sensitivity level (S_o)*. The selection of own ACAS sensitivity level shall be ~~determined by sensitivity level control (SLC) commands which shall be~~ accepted from a number of sources as follows:

a) ~~SLC command~~ sensitivity level generated automatically by ACAS based on altitude band or other external factors;

b) ~~SLC command~~ sensitivity level from pilot input; and

c) for TCAS Version 7.1 compliant systems: sensitivity level control (SLC) command from Mode S ground stations.

Note. — ~~ACAS X compliant systems acknowledge SLC commands from ground stations so that the ground stations do not need to be modified for these commands. However, the~~The ~~sensitivity level~~SLC value from a Mode S ground station is not used in ACAS X compliant systems.

~~Table 4-2~~

~~For TCAS Version 7.1 compliant systems:~~

~~Sensitivity level~~	*~~2~~*	*~~3~~*	*~~4~~*	*~~5~~*	*~~6~~*	*~~7~~*
~~Nominal warning time~~	~~no RAs~~	~~15s~~	~~20s~~	~~25s~~	~~30s~~	~~35s~~

4.3.4.3.1 *Permitted ~~SLC command codes~~sensitivity levels.* ~~As a minimum, the~~The acceptable ~~SLC command codes~~sensitivity levels shall include:

	~~Coding~~Values	
for ~~SLC~~ sensitivity level based on altitude band	2-7	(for TCAS Version 7.1 compliant systems)
	2-3	(for ACAS X compliant systems)
for ~~SLC~~ sensitivity level from pilot input	~~0,1,2~~1-2	
for SLC commands from Mode S ground stations	~~0,~~2-~~6~~7	(for TCAS Version 7.1 compliant systems)

4.3.4.3.2 *Altitude-band ~~SLC command~~sensitivity level*. Where ACAS selects ~~an SLC command~~a sensitivity level based on altitude, hysteresis shall be applied to the nominal altitude thresholds at which ~~SLC command~~sensitivity level value changes are required. ~~as follows: for~~For a climbing ACAS aircraft, the ~~SLC command~~sensitivity level shall be increased at the appropriate altitude threshold plus the hysteresis value~~;~~. ~~for~~For a descending ACAS aircraft, the ~~SLC command~~sensitivity level shall be decreased at the appropriate altitude threshold minus the hysteresis value.

4.3.4.3.3 *Pilot ~~SLC command~~sensitivity level*. ~~For the SLC command set by the pilot the value 0 shall indicate the~~The selection of a mode in which RAs can be issued shall result in the “automatic” mode, ~~for which~~indicating that the sensitivity level selection shall be based on ~~the~~ other ~~commands~~sources. The selection of a mode in which RAs are inhibited shall result in a sensitivity level of 2. The selection of “standby” shall result in a sensitivity level of 1.

Note.— The “automatic” mode is often referred to as a selection value of 0.

4.3.4.3.4 *Mode S ground station SLC command.*

4.3.4.3.4.1 For TCAS Version 7.1 compliant systems: For SLC commands transmitted via Mode S ground stations (4.3.8.4.2.1.~~1~~3), ~~the value~~an SLC of 0 shall indicate that the station concerned is not issuing an SLC command and that sensitivity level selection shall be based on ~~the~~ other ~~commands~~sources, including non-0 commands from other Mode S ground stations. ACAS shall not process ~~an~~ uplinked SLC values of 1 and 8-14.

Note.— An SLC of 0 ("no command issued") is often referred to as a selection value of 0.

4.3.4.3.4.2 For ~~ACAS X~~ACAS Xa compliant systems: ACAS shall receive any SLC commands from Mode S ground stations but shall not use their sensitivity level values.

4.3.4.3.4.3 *ATS selection of SLC command code.* ATS authorities shall ensure that procedures are in place to inform pilots of any ATS selected SLC command code other than 0 (4.3.4.3.1).

4.3.4.3.5 *Selection rule.* Own ACAS sensitivity level shall be set to the smallest ~~non-0 SLC command received~~sensitivity level requested from any of the sources listed in 4.3.4.3.

Note.— An SLC of 0 ("no command issued") and a pilot mode selection resulting in the "automatic" mode are not considered to be sensitivity level requests; rather, they defer the sensitivity level selection to other sources.

4.3.4.4 *Selection of parameter values for RA generation.* For TCAS Version 7.1 compliant systems: When the sensitivity level of own ACAS is 3 or greater, the parameter values used for RA generation that depend on sensitivity level shall be based on the greater of the sensitivity level of own ACAS, S_o, and the sensitivity level of the intruder's ACAS, S_i.

4.3.4.5 *Selection of parameter values for TA generation.* For TCAS Version 7.1 compliant systems: The parameter values used for TA generation that depend on sensitivity level shall be selected on the same basis as those for RAs (4.3.4.4) except when an SLC command with a value of 2 ~~("TA only" mode)~~ has been received from ~~either the pilot or~~ a Mode S ground station or when a pilot has selected the "TA only" mode. In ~~this case~~these cases, the parameter values for TA generation shall retain the values they would have had in the absence of the SLC command ~~from the pilot~~ or ~~Mode S ground station~~pilot mode selection.

Rationale

The changes in 4.3.4 about the selection of a sensitivity level arise from the following remarks:

- the former text used SLC everywhere whereas the term is used in the reference MOPS just to refer to commands from a ground station: sensitivity level is now used instead
- the explanation of the interaction between different sources of sensitivity levels was confusing: the text was clarified
- sensitivity level 7 was missing

4.3.4.6 *Validation of ADS-B tracks for RA generation.* For ACAS ~~X compliant~~ systems that use ADS-B tracks for RA generation: ~~I~~if ADS-B tracks fail validation via active interrogation and reply, via airborne primary surveillance radar or via EO/IR sensor, ACAS shall ~~revert back to using active surveillance for threat resolution logic~~exclude ADS-B surveillance data from RA generation.

Note 1.— Only validated ADS-B is used in the generation of RAs.

Note 2.— An ADS-B track under hybrid surveillance is considered validated via active interrogation and reply as it underwent the validation described in 4.5.1.3.2. If not under hybrid surveillance, the ADS-B track can be validated via active interrogation and reply, via airborne primary surveillance radar or via EO/IR sensor using suitable tests. Further information about ADS-B track validation can be found in RTCA DO-386 Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) *Section 2.2.5.1.4.*

Rationale

This PfA introduces the optional use of sensors to track non-cooperative aircraft. The provisions above were expanded to take into account the possibility to validate ADS-B tracks through this kind of active surveillance in addition to transponder interrogation.

…

4.3.5.3.1 ~~New ACAS installations after 1 January 2014~~ACAS shall monitor own aircraft's vertical rate to verify compliance with the RA sense. If noncompliance is detected, ACAS ~~shall stop assuming compliance, and instead~~ shall assume the observed vertical rate instead of assuming compliance.

Note 1.— This overcomes the retention of an RA sense that would work only if followed. The revised vertical rate assumption is more likely to allow the logic to select the opposite sense when it is consistent with the non-complying aircraft's vertical rate.

Note 2.— Equipment complying with RTCA/DO-185 or DO-185A standards (also known as TCAS Version 6.04A or TCAS Version 7.0) do not comply with this requirement.

Note 3.— Compliance with this requirement can be achieved through the implementation of traffic alert and collision avoidance system (TCAS) Version 7.1 as specified in RTCA/DO-185B or EUROCAE/ED-143 ~~or airborne collision avoidance system X (ACAS Xa — active surveillance and Xo — operation specific) as specified in RTCA/DO 385 or EUROCAE/ED-256~~, airborne collision avoidance system Xa/Xo (ACAS Xa-active surveillance, Xo-operation specific) as specified in RTCA/DO 385 or EUROCAE/ED-256, or airborne collision avoidance system Xu (ACAS Xu-unmanned aircraft systems) as specified in RTCA/DO-386 or EUROCAE/ED-275.

~~4.3.5.3.2 **Recommendation.**— *All ACAS should be compliant with the requirement in 4.3.5.3.1.*~~

~~4.3.5.3.3 After 1 January 2017, all ACAS units shall comply with the requirements stated in 4.3.5.3.1.~~

Rationale

It is no longer useful to retain the provisions which governed the transition to ACAS systems that monitor their own compliance with a vertical RA. Only the general requirement is retained, without an applicability date. In addition the list of complying existing systems is corrected and updated.

…

4.3.5.4.2 ~~ACAS shall operate in TA only mode~~RAs shall be inhibited when own aircraft is below 300 m (1 000 ft) AGL nominal value with hysteresis applied.

Rationale

ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

…

4.3.5.5.2 *Sense reversals due to inadequate predicted separation.* ACAS shall initiate not more than one vertical reversal per threat per encounter due to inadequate predicted separation.

Rationale

This limitation in the number of sense reversals is not necessary in the horizontal dimension (ACAS III), as proven by safety studies during the validation of ACAS Xu

…

4.3.5.6 *RA strength retention.* Subject to the requirement that a descend RA is not generated at low altitude (4.3.5.4.1), an RA shall not be modified if the time to closest approach is too short to achieve a significant response or if the threat is diverging in range.

…

4.3.5.10 SYSTEM RESPONSE TIME

Note .— The system delay described in this section does not include the pilot response delay which begins at the presentation of the RA on the display

4.3.5.10.1 For ACAS II systems: ~~The~~the system delay from receipt of the relevant SSR reply to presentation of an RA ~~sense and strength~~ to the pilot ~~shall be as short as possible and~~ shall not exceed 1.5 s.

Rationale
The removed "sense and strength" is unneeded detail. The requirement to be as short as possible is removed because it has no added value.

4.3.5.10.2 For ACAS III systems: the system delay from receipt of the relevant surveillance measurement to presentation of the RA to the pilot or to the RA interface of the flight control system shall not exceed 2.3 s.

Rationale
This is the value validated in the reference ACAS III system, ACAS Xu.

…

4.3.6 Coordination and communication

4.3.6.1 PROVISIONS FOR COORDINATION WITH ACAS-EQUIPPED THREATS

Note 1.— The provisions in this section apply to aircraft that coordinate with ACAS equipped aircraft via 1030/1090 MHz discrete Mode S interrogations/replies.

Note 2.— ACAS equipment not capable of utilizing 1030/1090 MHz discrete Mode S interrogations/replies ~~and that will use ADS-B to convey the applicable coordination scheme is under development~~may perform passive coordination over ADS-B using the protocols in Chapter 3 of RTCA/DO-382 or EUROCAE/ED-264. ACAS X compliant systems incorporate the ability to coordinate with threats using such ACAS equipment. ~~For more details, refer to Section 2.2.3.9.3.1 of RTCA/DO385 or EUROCAE/ED-256.~~

Rationale
The way through which ACAS equipment not capable of utilizing 1030/1090 MHz discrete Mode S interrogations/replies may perform coordination is now defined and the applicable industry standards are referenced.

…

4.3.6.1.3.6 When a Horizontal RA is selected, the Horizontal RAC (HRC) (4.3.8.4.2.3.2.4) that ACAS includes in a resolution message to the threat shall be as follows:

a) "do not turn left" or

b) "do not turn right"

Note..— The message indicates the sense of the RA (either turn right or turn left) issued by own aircraft's ACAS.

Rationale
ACAS III can issue horizontal RAs and has to communicate their sense for the coordination with other equipped aircraft.

…

4.3.6.3 PROVISIONS FOR DATA TRANSFER BETWEEN ACAS AND ITS MODE S TRANSPONDER

4.3.6.3.1 Data transfer from ACAS to its Mode S transponder:

a) ACAS shall transfer RA information to its Mode S transponder for transmission in an RA report (4.3.8.4.2.2.1, 4.3.8.4.2.2.2, and 4.3.8.4.2.2.3) and in a coordination reply (4.3.8.4.2.4.2), and to set the appropriate DR code in DF = 4, 5, 20, and 21 replies;

b) ACAS shall transfer current sensitivity level to its Mode S transponder for transmission in a sensitivity level report (4.3.8.4.2.5); ~~and~~

~~c) ACAS shall transfer capability information to its Mode S transponder for transmission in a data link capability report (4.3.8.4.2.2.2).~~

Note.— For ACAS X compliant systems: ACAS ~~will~~ does not transfer a sensitivity level value greater than 3 as part of the capability information to its Mode S transponder.

c) ACAS shall transfer capability information to its Mode S transponder for transmission in a data link capability report (4.3.8.4.2.2.4) and for transmission in the RI field of air-air downlink formats (DF = 0 and 16) (4.3.8.4.1.2); and

d) For ACAS X compliant systems: if ACAS has determined that its associated Mode S transponder is version 6 or later, ACAS shall transfer capability information to its Mode S transponder for transmission in the ADS-B Aircraft Operational Status Message (4.3.8.4.2.7.2).

4.3.6.3.2 Data transfer from Mode S transponder to its ACAS:

a) ACAS II shall receive from its Mode S transponder SLC commands (4.3.8.4.2.1.~~1~~3) transmitted by Mode S ground stations;~~.~~

Note.— For ACAS X compliant systems: ~~it is necessary to receive SLC commands from the transponder to be compliant with the interface protocols between the Mode S transponder and the ACAS unit; however,~~ the sensitivity level values are not used (refer to 4.3.4.3.4).

b) ACAS shall receive from its Mode S transponder ACAS broadcast messages (4.3.8.4.2.3.3) transmitted by other ACAS;~~ and~~

c) ACAS shall receive from its Mode S transponder resolution messages (4.3.8.4.2.3.2) transmitted by other ACAS for air-air coordination purposes~~.~~;

d) ACAS shall receive from its Mode S transponder own aircraft's Mode A identity data for transmission in an RA broadcast (4.3.8.4.2.3.4.1.5);

e) ACAS shall receive from its Mode S transponder the 24-bit aircraft address;

f) ACAS shall receive from its Mode S transponder the pressure altitude from the source that is the basis for own altitude in Mode C and Mode S replies;

g) ACAS shall receive from its Mode S transponder the quantization for pressure altitude (fine [10 feet or less] or coarse [more than 10 feet]); and

h) ACAS shall receive from its Mode S transponder the Mode S subnetwork version

i) ACAS III shall receive from its Mode S transponder own aircraft's ability to transmit OCMs.

…

4.3.7.1.2 *SURVEILLANCE OF MODE S TRANSPONDERS*

4.3.7.1.2.1 *Detection.* ~~ACAS shall monitor 1090 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~~ and extended squitters (DF = 17) by monitoring 1090 MHz.

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~~.

Rationale
The note is clarified.

~~*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.*~~

Rationale
It is no longer planned to rely only on the extended squitter for aircraft acquisition.

…

4.3.7.2 AIR-AIR COORDINATION PROTOCOLS

Note 1.— The provisions in this section apply to aircraft that coordinate with ACAS equipped aircraft via 1030/1090 MHz discrete Mode S interrogations/replies.

Note 2.— ACAS equipment not capable of utilizing 1030/1090 MHz discrete Mode S interrogations/replies ~~and that will use ADS-B to convey the applicable coordination scheme is under development~~may perform passive coordination over ADS-B using the protocols in RTCA/DO-382 or EUROCAE/ED-264. ACAS X compliant systems incorporate the ability to coordinate with threats using such ACAS equipment. ~~For more details, refer to Section 2.2.3.9.3.1 of RTCA/DO-385 or EUROCAE/ED-256.~~

Rationale
The way through which ACAS equipment not capable of utilizing 1030/1090 MHz discrete Mode S interrogations/replies may perform coordination is now defined and the applicable industry standards are referenced.

4.3.7.2.1 *Coordination interrogations.* ACAS shall transmit UF = 16 interrogations (Chapter 3, 3.1.2.3.2, Figure 3-7) with AQ = 0 and RL = 1 when another aircraft reporting RI = 3 or 4 is declared a threat (4.3.4). The MU field shall contain the resolution message in the subfields specified in 4.3.8.4.2.3.2.

Note 1.— A UF = 16 interrogation with AQ = 0 and RL = 1 is intended to cause a DF = 16 reply from the other aircraft.

Note 2.— ~~An aircraft reporting RI = 3 or RI = 4 is an aircraft equipped with an operating ACAS which has vertical only or vertical and horizontal resolution capability, respectively~~Transmitted RI is restricted to values from 0 to 3 or from 8 to 15 (maximum airspeed information) (see 4.3.8.4.1.2). TCAS installations from different manufacturers treat RI values between 4 and 7 inconsistently; use of these values can result in the malfunction of equipment. In particular, reporting RI=4 can result in own aircraft being treated as unequipped by some TCAS. Legacy standards documents have described the use of RI=4 to declare a CAS capable of generating both vertical and horizontal RAs. If ACAS Xu or Xa receives RI=4, it treats the threat as CAS-equipped and coordinates with it, as the most probable reason the threat has transmitted RI=4 is that it is intending to announce itself as CAS-equipped and is capable of both vertical and horizontal RAs.

Rationale
Clarification on the reporting of RI=4. Legacy standards (e.g. TCAS II 7.0) refers to a definition of RI=4 that is no longer valid.

…

4.3.7.3.4.2 For ACAS X compliant systems: ~~ACAS shall receive any SLC commands from Mode S ground stations but shall not use their sensitivity level values~~ACAS shall not use SLC commands received from ground stations via a Mode S transponder.

Rationale
Text simplification.

…

4.3.8.4.1.2 *RI (air-air reply information).* The significance of the coding in the RI field shall be as follows:

Coding	
0	No operating ~~ACAS~~CAS
1	~~Not assigned~~Active CAS of junior status with resolution capability or Passive CAS with resolution capability and a Mode S transponder
2	~~A~~Any CAS with resolution capability inhibited
3	~~ACAS with vertical-only resolution capability and capability to utilize 1030/1090 MHz discrete Mode S interrogations/replies for coordination~~ Active CAS with resolution capability
~~4~~	~~ACAS with vertical and horizontal resolution capability and capability to utilize 1030/1090 MHz discrete Mode S interrogations/replies for coordination~~
~~5-6~~	~~Reserved for passive ACAS~~
4-7	~~Not~~Must not be assigned
8-15	See Chapter 3, 3.1.2.8.2.2

Bit 14 of the reply format containing this field shall replicate the AQ bit of the interrogation. The RI field shall report "no operating ~~A~~CAS" (RI = 0) if the ACAS unit has failed or is in standby. The RI field shall report "~~A~~CAS with resolution capability inhibited" (RI = 2) if sensitivity level is 2 or TA only mode has been selected.

Note 1.— An active CAS of junior status is a CAS that has active 1030/1090 MHz interrogation/ reply capability but is required by regulatory authorities to perform responsive coordination in encounters with an aircraft reporting 3-bit CCCB Aircraft CAS Type/Capability values equal to 000, 001, or 010. For further details, refer to EUROCAE/ED-264 or RTCA/DO-382

Rationale
Significance of the coding is updated in line with the MASPS Interoperability for ACAS systems, referenced in Note 1 above.

Note 2.— Codes 0-7 in the RI field indicate that the reply is a tracking reply and also give the ACAS capability of the interrogated aircraft. Codes 8-15 indicate that the reply is an acquisition reply and also give the maximum true airspeed capability of the interrogated aircraft.

Note 3.— TCAS installations from different manufacturers treat Codes 4-7 in the RI field inconsistently; use of these values can result in the malfunction of equipment. In particular, reporting RI=4 can result in own aircraft being treated as unequipped by some TCAS.

Rationale
Clarification on the reporting of RI=4.

…

4.3.8.4.2.1.3 *SLC (ACAS sensitivity level control (SLC) command).* This 4-bit (41-44) subfield shall denote a sensitivity level command for own ACAS.

…

Note 2.— ACAS Xa compliant systems receive SLC commands but their -sensitivity level values are not used.

Note 3.— ACAS III systems do not receive or use SLC commands.

33	37	41	45
ADS1 = 0	ADS2 = 5	SLC	- - - - - 44 - - - - -
36	40	44	88

4.3.8.4.2.2 *Subfields in MB*

~~*Note.— 4.3.8.4.2.2.1 is applicable to TCAS Version 7.1 compliant systems, while 4.3.8.4.2.2.2 is applicable to ACAS X compliant systems 4.3.8.4.2.2.3 is applicable to both TCAS Version 7.1 and ACAS X compliant systems.*~~

…

4.3.8.4.2.2.2 *For ACAS Xa compliant systems: Subfields in MB for an RA report.* When BDS1=3 and BDS2=0, the subfields indicated below shall be contained in MB.

4.3.8.4.2.2.2.1 *ARA (active RAs).* This 10-bit (41-50) subfield shall indicate the currently active RA if any generated by own ACAS X unit against one or more threat aircraft.

The ARA subfield is further divided into:

a) *AVRA (vertical RA).* This 7-bit (41-47) subfield contains the vertical component of the ARA as defined below; and

b) *AHRA (horizontal RA)*. This 3-bit (48-50) subfield contains the horizontal component of the ARA. For ACAS Xa compliant systems, AHRA=0.

…

4.3.8.4.2.2.3 For ACAS III compliant systems: Subfields in MB for an RA report. The report consists of two parts: the first part when UDS1 = 3 and UDS2 = 0, the second part when UDS1=3 and UDS2=1.
When UDS1=3 and UDS2=0, the subfields indicated from 4.3.8.4.2.2.3.1 to 4.3.8.4.2.2.3.10 shall be contained in MB.
When UDS1=3 and UDS2=1, the subfields indicated from 4.3.8.4.2.2.3.11 to 4.3.8.4.2.2.3.19 shall be contained in MB.

4.3.8.4.2.2.3.1 AVRA (active vertical RA). This 7-bit (41-47) subfield contains the vertical component of the active RA (ARA) subfield and shall be coded as defined in 4.3.8.4.2.2.2.1. AVRA equals ZERO in this 56-bit message whenever VRAT=1 in the RA report.

4.3.8.4.2.2.3.2 AHRA (active horizontal RA). This 9-bit (48-52 and 55-58) subfield contains the horizontal component of the active RA (ARA) subfield and shall be coded as defined below. AHRA equals ZERO in this 56-bit message whenever HRAT=1 in the RA report.

Bits 48-52 shall have the following meanings:

Bit	Coding	
48	0	Different horizontal senses have been generated in a multi-threat encounter (when HMTE=1); or no horizontal RA has been generated (when HMTE=0)
	1	The same horizontal sense has been generated in a single or multi-threat encounter
49-50		Turn left / turn right bits are set to indicate the direction of turn required to comply with the horizontal guidance and target track angle as shown below.

Turn left / right bit mapping

49	50	Value	Meaning
0	0	= 0	No horizontal advisory / horizontal RA clear
0	1	= 1	Turn right
1	0	= 2	Turn left
1	1	= 3	Not assigned

51	Target track angle bit 1
52	Target track angle bit 2

Bits 55-58 shall have the following meanings:

Bit	Coding
55	Target track angle bit 3
56	Target track angle bit 4
57	Target track angle bit 5
58	Target track angle bit 6

The mapping/meaning of the AHRA subfield target track angle bits (51-52 and 55-58) is defined as follows:

AHRA subfield target track angle bit mapping

51	52	55	56	57	58	Value	Meaning
0	0	0	0	0	0	= 0	Track angle 360/000
0	0	0	0	0	1	= 1	Track angle 010
0	0	0	0	1	0	= 2	Track angle 020
0	0	0	0	1	1	= 3	Track angle 030
0	0	0	1	0	0	= 4	Track angle 040
0	0	0	1	0	1	= 5	Track angle 050
0	0	0	1	1	0	= 6	Track angle 060
0	0	0	1	1	1	= 7	Track angle 070
0	0	1	0	0	0	= 8	Track angle 080
0	0	1	0	0	1	= 9	Track angle 090
0	0	1	0	1	0	= 10	Track angle 100
0	0	1	0	1	1	= 11	Track angle 110
0	0	1	1	0	0	= 12	Track angle 120
0	0	1	1	0	1	= 13	Track angle 130
0	0	1	1	1	0	= 14	Track angle 140
0	0	1	1	1	1	= 15	Track angle 150
0	1	0	0	0	0	= 16	Track angle 160
0	1	0	0	0	1	= 17	Track angle 170
0	1	0	0	1	0	= 18	Track angle 180
0	1	0	0	1	1	= 19	Track angle 190
0	1	0	1	0	0	= 20	Track angle 200
0	1	0	1	0	1	= 21	Track angle 210
0	1	0	1	1	0	= 22	Track angle 220
0	1	0	1	1	1	= 23	Track angle 230
0	1	1	0	0	0	= 24	Track angle 240
0	1	1	0	0	1	= 25	Track angle 250
0	1	1	0	1	0	= 26	Track angle 260
0	1	1	0	1	1	= 27	Track angle 270
0	1	1	1	0	0	= 28	Track angle 280
0	1	1	1	0	1	= 29	Track angle 290
0	1	1	1	1	0	= 30	Track angle 300
0	1	1	1	1	1	= 31	Track angle 310

1	0	0	0	0	0	= 32	Track angle 320
1	0	0	0	0	1	= 33	Track angle 330
1	0	0	0	1	0	= 34	Track angle 340
1	0	0	0	1	1	= 35	Track angle 350
1	1	1	1	1	1	= 63	No target track angle / horizontal RA Clear

4.3.8.4.2.2.3.3 RMF (RA message format). This 2-bit (53-54) subfield indicates the CA system used to generate bits 41-88 of the RF message and shall be coded as defined below.

Bit 53	Bit 54	Value	Meaning
0	0	= 0	TCAS II
0	1	= 1	ACAS Xa
1	0	= 2	ACAS Xu
1	1	= 3	Not assigned

4.3.8.4.2.2.3.4 RAT (RA terminated indicator). This 1-bit (59) subfield indicates when the RA previously generated by CAS has ceased being generated and shall be coded as defined below.

Coding	
0	The RA indicated by one or both of the AVRA and AHRA subfields is currently active.
1	The RA indicated by the AVRA and AHRA subfields has been terminated.

Note 1.—After an RA has been terminated by ACAS III, it is still required to be reported by the Mode S transponder for 18±1 seconds (RA report and ADS-B TCAS RA broadcast). The RA terminated indicator may be used, for example, to permit timely removal of an RA indication from an air traffic controller's display, or for assessments of RA duration within a particular airspace.

Note 2.—RAs may terminate for a number of reasons: normally, when the conflict has been resolved and the threat is diverging in range; or when the threat's Mode S transponder for some reason ceases to report altitude during the conflict. The RA terminated indicator is used to show that the RA has been removed in each of these cases.

Note 3. —The overall RAT (bit 59) is meant to be used in conjunction with the individual VRAT (bit 87) and HRAT (bit 88) to determine the status of the RA in each dimension on the previous cycle (see table 4-3). A VRAT or HRAT setting of 1 reflects only that an RA is terminated in one dimension while an RA is still active in the other. When all RAs are terminated, the RAT (bit 59) is set to 1 and all of the subfields from the previous cycle are frozen, including the settings of VRAT and HRAT and their associated AVRA, AHRA, VMTE, HMTE, TTI, TID, LDI, HRI, RAC, CCB, ICO, CCB2, ICO2, TTI2, and TID2 information. If RAT is set to 1 and both VRAT and HRAT are set to 0, the RA terminated in both dimensions on the same cycle, or the RA was only in one dimension.

Table 4-3. Settings of RAT, VRAT, and HRAT for the 18/24s Freeze Period

RAT (bit 59)	VRAT (bit 87)	HRAT (bit 88)	Meaning
1	0	0	RA is terminated; VRA and HRA terminated on the same cycle OR The RA was in only one dimension
1	0	1	RA is terminated; HRA terminated before VRA
1	1	0	RA is terminated; VRA terminated before HRA

4.3.8.4.2.2.3.5 VMTE (vertical multiple-threat encounter). This 1-bit (60) subfield indicates whether two or more simultaneous threats are currently contributing to the vertical component of the RA and shall be coded as defined below.

Coding	
0	A single threat is contributing to the vertical component of the RA (when AVRA bit 41=1); or no vertical RA component is being generated (when AVRA bit 41=0).
1	Two or more simultaneous threats are currently contributing to the vertical component of the RA, or there is a single threat in the vertical dimension and a different single threat in the horizontal dimension.

Note 1.—The full MTE state needs *be determined by examining both VMTE and HMTE.*

Note 2.—When there is a single threat in the vertical dimension and a different single threat in the horizontal dimension, a multi-threat encounter would not be indicated if both VMTE and HMTE are both set to 0. Therefore, in this case both VMTE and HMTE are set to 1.

4.3.8.4.2.2.3.6 HMTE (horizontal multiple-threat encounter). This 1-bit (61) subfield indicates whether two or more simultaneous threats are currently contributing to the horizontal component of the RA and shall be coded as defined below.

Coding	
0	A single threat is contributing to the horizontal component of the RA (when AHRA bit 48=1); or no horizontal RA component is being generated (when AHRA bit 48=0).
1	Two or more simultaneous threats are currently contributing to the horizontal component of the RA, or there is a single threat in horizontal dimension and a different single threat in the vertical dimension.

Note 1.—The full MTE state needs be determined by examining both VMTE and HMTE.

Note 2.— When there is a single threat in the vertical dimension and a different single threat in the horizontal dimension, a multi-threat encounter would not be indicated if both VMTE and HMTE were set to 0. Therefore, in this case both VMTE and HMTE are set to 1.

4.3.8.4.2.2.3.7 TTI (threat type indicator). This 1-bit (62) subfield defines the type of identity data contained in the TID subfield and shall be coded as defined below.

Coding	
0	TID contains altitude, range, and bearing data
1	TID contains an ICAO 24-bit aircraft address

4.3.8.4.2.2.3.8 TID (threat identity data). This 24-bit (63-86) subfield contains the 24-bit aircraft address of the threat or the altitude, range, and bearing if the threat is not reporting a 24-bit address. The 24-bit address may be a non-ICAO address. If TTI=1, TID shall contain in bits 63-86 the 24-bit aircraft address of the threat. If TTI=0, TID shall contain the following three subfields.

Note. —Part one of the RA report is contained in register 30_{16}*, and part two is contained in register* 31_{16}*. Only register* 30_{16} *contents are routinely extracted by Mode S ground stations, meaning that the TID2 subfield in register* 31_{16} *may not always be accessible. Therefore, in the case of multiple threats, the RA report formatting logic rotates through the threats so that each threat's identity data will appear in the register* 30_{16} *TID subfield for at least one (one-second) cycle.*

4.3.8.4.2.2.3.8.1 TIDA (threat identity data altitude). This 11-bit (63-73) subfield contains the most recent threat altitude estimated by ACAS III, expressed in binary to a resolution of 100 ft, and shall be coded as follows:

Coding	
0	No altitude data

1	Altitude below -950 ft
2	-950 ft ≤ altitude < -850 ft
3	-850 ft ≤ altitude < -750 ft
…	....

4.3.8.4.2.2.3.8.2 TIDR (threat identity data range). This 7-bit (74-80) subfield contains the most recent threat range estimated by ACAS III (horizontal range) and shall be coded as defined below.

Coding(n)

n	Estimated range (NM)
0	No range estimate available
1	Less than 0.05
2-126	(n-1)/10 ±0.05
127	Greater than 12.55

4.3.8.4.2.2.3.8.3 TIDB (threat identity data bearing). This 6-bit (81-86) subfield contains the most recent estimated bearing of the threat aircraft and shall be coded relative to the ACAS III aircraft heading as follows:

Coding(n):

n	Estimated bearing (degrees)
0	No bearing estimate available
1-60	Between 6(n-1) and 6n
61-63	Not assigned

4.3.8.4.2.2.3.9 VRAT (vertical RA terminated). This 1-bit (87) subfield shall be coded as defined below:

Coding

0	The RA indicated by the AVRA subfield is active
1	The vertical component of the RA has been terminated but the horizontal component of the RA is still active

Note.— When VRAT is set to 1, the values in the VMTE and AVRA subfields reflect the terminated vertical component of the RA. Those values of VRAT, VMTE, and AVRA persist until either there is a new vertical component of the RA or the RA has terminated, in both dimensions, and RAT is no longer set to 1. See Table *4-3.*

4.3.8.4.2.2.3.10 HRAT (horizontal RA terminated). This 1-bit (88) subfield shall be coded as defined below.

Coding

0	The RA indicated by the AHRA subfield is active
1	The horizontal component of the RA has been terminated but the vertical component of RA is still active

Note 1.— When HRAT is set to 1 the values in the HMTE and AHRA subfields reflect the terminated horizontal component of the RA. Those values of HRAT, HMTE, and AHRA persist until either there is a new horizontal component of the RA or the RA has terminated, in both dimensions, and RAT is no longer set to 1. See Table 4-3.

Note 2.—The overall RAT (bit 59) indicates the termination of the RA in both dimensions. When both RA dimensions are terminated, the RAT is set to 1 and the information in all other subfields is preserved from the previous cycle, including the AVRA, AHRA, VMTE, HMTE, TTI, TID, VRAT, HRAT, LDI, HRI, RAC, CCB, ICO, CCB2, ICO2, TTI2, and TID2 subfields. An individual VRAT (bit 87) or HRAT (bit 88) setting of 1 reflects only that an RA terminated in the associated dimension at the same time an RA was active in the other dimension. When VRAT is set to 1 due to vertical RA termination with a horizontal RA still active, the information in AVRA and VMTE is preserved every cycle until and including the cycle that the horizontal *dimension terminates and RAT becomes 1. When HRAT is set to 1 due to horizontal RA termination with a vertical RA still active, the information in AHRA and HMTE is preserved every cycle until and including the cycle that the vertical dimension terminates and RAT becomes 1. The VRAT and HRAT bits are not changed from their settings on the previous cycle when RAT becomes 1.*

Note.— Structure of MB for an RA report part 1:

33	37	41	48	53	55	59	60	61	62	63	74	81	87	88
UDS1 = 3	UDS2 = 0	AVRA	AHRA1	RMF	AHRA2	RAT	VMTE	HMTE	TTI	TIDA	TIDR	TIDB	VRAT	HRAT
										TID				
36	40	47	52	54	58	60	60	61	62	73	80	86	87	88

4.3.8.4.2.2.3.11 LDI (low-level descend inhibit). This 2-bit (41-42) subfield indicates whether low level descend inhibit is being applied and shall be coded as defined below.

Bit 51	Bit 52	Value	Meaning
0	0	0	No RAs are inhibited in the vertical dimension
0	1	1	Increased rate descend RAs are inhibited – but see Note 1
1	0	2	All positive descend RAs are inhibited
1	1	3	All RAs are inhibited in the vertical and horizontal dimensions –see Note 2

Note 1.—When own aircraft is descending, the continuation of active increased rate descend RAs is not inhibited unless all positive descend RAs are inhibited. The generation of new increased rate descend RAs is inhibited as indicated.

Note 2.—A hazardous condition arises when RAs are inhibited in the vertical dimension but not in the horizontal dimension. In this case, ACAS III would report RI=3 in its surveillance replies globally, even though it does not have a vertical RA capability. Intruders equipped with TCAS II would rely on ACAS III for geometric reversals that could never be generated. Thus LDI=3 indicates that all RAs are inhibited, in both the horizontal and vertical dimensions.

4.3.8.4.2.2.3.12 HRI (horizontal resolution advisory inhibit indicator). This 1-bit subfield (43) indicates whether or not own aircraft is below the altitude at which the horizontal components of RAs are provided by the ACAS III system and shall be coded as defined below.

Coding	
0	No RAs are inhibited in the horizontal dimension.
1	All RAs are inhibited in the horizontal dimension.

Note.—HRI will be set to 1 when LDI=3, since horizontal RAs are required to be inhibited whenever all vertical RAs are inhibited.

4.3.8.4.2.2.3.13 RAC (RA complements). This 4-bit (44-47) subfield indicates the currently active RA complements (if any) received from other aircraft equipped with an on-board CAS with resolution capability. The RA complements are received by own aircraft via TCAS resolution messages and OCMs. The presence of a bit setting in this subfield does not imply the value was used by the ACAS III resolution logic.

The bits in RAC have the following meanings:

Bit	RAC
55	Do not pass below received by own aircraft
56	Do not pass above received by own aircraft

57	Do not turn left received by own aircraft
58	Do not turn right received by own aircraft

A bit set to 1 indicates that the associated condition on at least one other CAS is active. A bit set to 0 indicates that the associated condition is inactive on all other CAS.

4.3.8.4.2.2.3.14 CCB (collision avoidance coordination capability bits). This 7-bit subfield (48-54) contains the CCCB settings received from the threat identified in TID (4.3.8.4.2.2.3.8) and shall be coded as defined in 4.3.8.4.2.7.2.4.3.

4.3.8.4.2.2.3.15 ICO (is ICAO 24-bit address): This 1-bit subfield (55) indicates whether the 24-bit address in TID (4.3.8.4.2.2.3.8) is an ICAO address and shall be coded as defined below.

ICO	TTI	TID
0	0	Altitude, range, and bearing
0	1	Non-ICAO (random) address
1	1	ICAO address

4.3.8.4.2.2.3.16 CCB2 (collision avoidance coordination capability bits 2). This 7-bit subfield (56-62) contains the CCCB settings received from the threat identified in TID2 (4.3.8.4.2.2.3.19) and shall be coded as defined in 4.3.8.4.2.7.2.4.3.

4.3.8.4.2.2.3.17 ICO2 (is ICAO 24-bit address 2). This 1-bit subfield (63) indicates whether the 24-bit address in TID2 (4.3.8.4.2.2.3.19) is an ICAO address and shall be coded as defined in 4.3.8.4.2.3.4.3.15.

4.3.8.4.2.2.3.18 TTI2 (threat type indicator 2). This 1-bit (64) subfield defines the type of identity data contained in TID2 (4.3.8.4.2.2.3.19) and shall be coded as defined in 4.3.8.4.2.2.3.7.

4.3.8.4.2.2.3.19 TID2 (threat identity data 2). This 24-bit (65-88) subfield contains the 24-bit aircraft address of the threat or the altitude, range, and bearing if the threat is not reporting a 24-bit address. The 24-bit address may be a non-ICAO address. If TTI2=1, TID2 shall contain in bits 65-88 the 24-bit aircraft address of the threat. If TTI2=0, TID2 shall contain the three subfields as defined in 4.3.8.4.2.2.3.8.

Note.— Structure of MB for an RA report part 2:

33	37	41	43	44	48	55	56	63	64	65	76	83
UDS1 = 3	UDS2 = 1	LDI	HRI	RAC	CCB	ICO	CCB2	ICO2	TTI2	TIDA2	TIDR2	TIDB2
										TID2		
36	40	42	43	47	54	55	62	63	64	75	82	88

Rationale
The RA report is a message sent on 1,090 MHz in response to a Mode S ground radar request during an RA and a short time after, for the purpose of ground monitoring. A new RA report format is needed to take into account horizontal RAs in ACAS III and add the capability to identify a second threat.

4.3.8.4.2.2.~~3~~4   *For all ACAS systems: 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*	
43-46	0000	TCAS Version 7.1 compliant and other systems defined by bits 71 and 72
	0001	ACAS Xa (RTCA/DO-385 and EUROCAE/ED-256)
	0010	ACAS Xu (RTCA/DO-386 and EUROCAE/ED-275)

	001~~0~~1 to 1111	Reserved ~~for ACAS III~~
48	0 ACAS failed or on standby 1 ACAS operating	
69	0 Hybrid surveillance not operational 1 Hybrid surveillance fitted and operational	
70	0 ACAS generating TAs only 1 ACAS generating TAs and RAs	

Bit 72	Bit 71	ACAS version
0	0	RTCA/DO-185 (pre-ACAS)
0	1	RTCA/DO-185A
1	0	RTCA/DO-185B and EUROCAE ED 143
1	1	All later systems (see ~~*Note 3 and*~~ *4.3.8.4.2.8*)

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 69.

~~*Note 3.— Future versions of ACAS will be identified using part numbers and software version numbers specified in registers* $E5_{16}$ *and* $E6_{16}$.~~

Rationale
Like previous standardized systems, ACAS Xu as an ACAS III system is included in the data link capability report to communicate the capability of the onboard equipment.

…

4.3.8.4.2.3.4 *Subfields in MU for an RA broadcast (RA broadcast interrogation message)*

Note. — 4.3.8.4.2.3.4.1 is only applicable to TCAS Version 7.1 compliant systems, while 4.3.8.4.2.3.4.2 is only applicable to ACAS Xa compliant systems and 4.3.8.4.2.3.4.3 is only applicable to ACAS III systems.

…

4.3.8.4.2.3.4.2 *For ACAS Xa compliant systems: Subfields in MU for an RA broadcast (RA broadcast interrogation message). When UDS1 = 3 and UDS2 = 1, the following* subfields shall be contained in MU:

…

4.3.8.4.2.3.4.3 *For ACAS III systems: Subfields in MU for an RA broadcast (RA broadcast interrogation message).* The broadcast is in two parts: the first part when UDS1 = 3 and UDS2 = 4, the second part when UDS1=3 and UDS2=5.

When UDS1 = 3 and UDS2 =4, the subfields indicated from 4.3.8.4.2.3.4.3.1 to 4.3.8.4.2.3.4.3.8 shall be contained in MU.
When UDS1 = 3 and UDS2 =5, the subfields indicated from 4.3.8.4.2.3.4.3.9 to 4.3.8.4.2.3.4.3.15 shall be contained in MU.

4.3.8.4.2.3.4.3.1 *AVRA (active vertical RA)*. This 7-bit (41-47) subfield contains the vertical component of the active RA (ARA) subfield and shall be coded as defined in 4.3.8.4.2.2.2.1. AVRA equals ZERO in this 56-bit message whenever VRAT=1 in the RA report (4.3.8.4.2.2.3.9).

4.3.8.4.2.3.4.3.2 *AHRA (active horizontal RA)*. This 9-bit (48-52 and 55-58) subfield contains the horizontal component of the active RA (ARA) subfield and shall be coded as defined in 4.3.8.4.2.2.3.2. AHRA equals ZERO in this 56-bit message whenever HRAT=1 in the RA Report (4.3.8.4.2.2.3.10).

4.3.8.4.2.3.4.3.3 *VMTE (vertical multiple threat encounter)*. This 1-bit (bit 57) subfield shall be coded as defined in 4.3.8.4.2.4.2.3.4. VMTE equals ZERO in this 56-bit message whenever VRAT=1 in the RA report (4.3.8.4.2.2.3.9).

4.3.8.4.2.3.4.3.4 *HMTE (horizontal multiple threat encounter)*. This 1-bit (bit 58) subfield shall be coded as defined in 4.3.8.4.2.4.2.3.5. HMTE equals ZERO in this 56-bit message whenever HRAT=1 in the RA Report (4.3.8.4.2.2.3.10).

4.3.8.4.2.3.4.3.5 *RAT (RA terminated indicator)*. This 1-bit (59) subfield indicates when the RA previously generated by CAS has ceased being generated and shall be coded as defined in 4.3.8.4.2.2.3.4.

4.3.8.4.2.3.4.3.6 *RAC (RA complements)*. This 4-bit (60-63) subfield shall be coded as defined in 4.3.8.4.2.2.1.2.

4.3.8.4.2.3.4.3.7 *MST (multiple single-dimensional threats)*. This 1-bit (bit 64) subfield is used to indicate that the overall multiple threat situation, as indicated by VMTE=1 and HTME=1, actually consists of a single threat in the vertical dimension and a different single threat in the horizontal dimension. It is used to distinguish that case from the case where two or more threats in the vertical dimension are combined with two or more threats in the horizontal dimension, the only other case where VMTE=1 and HMTE=1. The subfield shall be coded as defined below.

Coding	
0	There is a single threat overall (VMTE=0 and HMTE=0) or there are two or more threats in at least one dimension
1	There are two distinct threats overall and VMTE=1 and HTME=1, but there is only a single threat in each dimension

4.3.8.4.2.3.4.3.8 MID (ICAO aircraft address). This 24-bit (65-88) subfield shall contain the 24-bit aircraft address of the interrogating ACAS aircraft.

Note.— Structure of MU for an RA broadcast (RA broadcast interrogation message) Part 1

33	37	41	48	57	58	59	60	64	65
UDS1 = 3	UDS2 = 4	AVRA	AHRA	VMTE	HMTE	RAT	RAC	MST	MID
36	40	47	56	57	58	59	63	64	88

4.3.8.4.2.3.4.3.9 *LDI (low level descend inhibit)*. This 2-bit (41-42) subfield indicates whether low level descend inhibit is being applied and shall be coded as defined in 4.3.8.4.2.2.2.2.

4.3.8.4.2.3.4.3.10 *HRI (horizontal resolution advisory cutoff indicator)*. This 1-bit (bit 43) subfield indicates whether own aircraft is below the altitude at which the horizontal components of RAs are provided by the ACAS III system and shall be coded as defined in 4.3.8.4.2.2.3.12.

4.3.8.4.2.3.4.3.11 *CCB (collision avoidance coordination capability bits)*. This 7-bit subfield (44-50) contains the CCCB settings received from the threat identified in TID (4.3.8.4.2.3.4.3.14) and shall be coded as defined in 4.3.8.4.2.7.2.4.3.

4.3.8.4.2.3.4.3.12 *ICO (is ICAO 24-bit address)*. This 1-bit subfield (bit 51) indicates whether the 24-bit address in TID (4.3.8.4.2.3.4.3.14) is an ICAO address and shall be coded as defined in 4.3.8.4.2.2.3.15.

4.3.8.4.2.3.4.3.13 *TTI (threat type indicator)*. This 1-bit (bit 52) subfield defines the type of identity data contained in the TID subfield (4.3.8.4.2.3.4.3.14) and shall be coded as defined in 4.3.8.4.2.2.2.8.

4.3.8.4.2.3.4.3.14 *TID (threat identity data)*. This 24-bit (53-76) subfield contains the 24-bit aircraft address of the threat or the altitude, range and bearing if the threat is not reporting a 24-bit address. The 24-bit address may be a non-ICAO address, indicated by the ICO subfield (4.3.8.4.2.3.4.3.12). If TTI=1, TID shall contain in bits 53-76 the 24-bit aircraft address of the threat. If TTI=0, TID shall contain the following three subfields.

4.3.8.4.2.3.4.3.14.1 *TIDA (threat identity data altitude)*. This 11-bit (53-63) subfield contains the most recent threat altitude estimated by ACAS III, expressed in binary to a resolution of 100 ft, and shall be coded as defined in 4.3.8.4.2.2.2.9.1.

4.3.8.4.2.3.4.3.14.2 *TIDR (threat identity data range)*. This 7-bit (64-70) subfield contains the most recent threat range estimated by ACAS III (horizontal range) and shall be coded as defined in 4.3.8.4.2.2.2.9.2.

4.3.8.4.2.3.4.3.14.3 *TIDB (threat identity data bearing)*. This 6-bit (71-76) subfield contains the most recent estimated bearing of the threat aircraft, relative to the ACAS III aircraft heading, and shall be coded as defined in 4.3.8.4.2.2.2.9.3.

4.3.8.4.2.3.4.3.15 *HSH (hash code)*. This 8-bit (80-88) subfield shall contain a coded value used to associate this 56-bit message to part one (UDS=34_{16}) of an RA broadcast interrogation from the same aircraft on the same ACAS III processing cycle. The coded value is derived from data in part one. The purpose of this subfield is strictly to associate the two parts of a single RA broadcast interrogation.

Note.—The address in the AP field in any RA broadcast interrogation is always all 1s; the 24-bit ICAO address for own aircraft is not available from that field. MID, the 24-bit ICAO address for own aircraft, is included only in part one of an RA broadcast interrogation, so HSH allows a monitor to associate the MID value in part one with the contents of part two.

Note.— Structure of MU for an RA broadcast (RA broadcast interrogation message) Part 2:

33	37	41	43	44	51	52	53	64	71	77	81
UDS1 = 3	UDS2 = 5	LDI	HRI	CCB	ICO	TTI	TIDA	TIDR	TIDB	Not assigned	HSH
							TID				
36	40	42	43	50	51	52	63	70	76	80	88

Rationale

The RA broadcast is a periodic message sent on 1,030 MHz during an RA and a short time after, for the purpose of ground monitoring. A new RA broadcast format is needed to take into account horizontal RAs in ACAS III.

…

4.3.8.4.2.4.2 *Subfields in MV for a coordination reply*

Note. — 4.3.8.4.2.4.2.1 is only applicable to TCAS Version 7.1 compliant systems, while 4.3.8.4.2.4.2.2 is only applicable to ACAS Xa compliant systems and 4.3.8.4.2.4.2.3 is only applicable to ACAS III systems.

…

4.3.8.4.2.4.2.2 *For ACAS Xa compliant systems: Subfields in MV for a coordination reply*. When VDS1 = 3 and VDS2 = 0, the following subfields shall be contained in MV:

…

4.3.8.4.2.4.2.3 *For ACAS III systems: Subfields in MV for a coordination reply*. When VDS1 = 3 and VDS2 = 0, the following subfields shall be contained in MV:

4.3.8.4.2.4.2.3.1 *ARA (active RAs)*. This 16-bit (41-52, 55-58) subfield shall be coded as defined in 4.3.8.4.2.2.3.1 and 4.3.8.4.2.2.3.1.

4.3.8.4.2.4.2.3.2 *RMF (RA message format)*. This 2-bit (53-54) subfield shall be coded as defined in 4.3.8.4.2.2.3.3.

4.3.8.4.2.4.2.3.3 *RAT (RA terminated indicator)*. This 1-bit (59) subfield shall be coded as defined in 4.3.8.4.2.2.3.4.

4.3.8.4.2.4.2.3.4 V*MTE (Vertical multiple threat encounter)*. This 1-bit (60) subfield shall be coded as defined in

4.3.8.4.2.2.3.5.

4.3.8.4.2.4.2.3.5 *HMTE (Horizontal multiple threat encounter).* This 1-bit (61) subfield shall be coded as defined in 4.3.8.4.2.2.3.6.

4.3.8.4.2.4.2.3.6 *TTI (Threat Type Indicator).* This 1-bit (62) subfield shall be coded as defined in 4.3.8.4.2.2.3.7.

4.3.8.4.2.4.2.3.7 *TID (Threat ID).* This 24-bit (63-86) subfield shall be coded as defined in 4.3.8.4.2.2.3.8.

4.3.8.4.2.4.2.3.8 *VRAT (Vertical RAT).* This 1-bit (87) subfield shall be coded as defined in 4.3.8.4.2.2.3.9.

4.3.8.4.2.4.2.3.9 *HRAT (Horizontal RAT).* This 1-bit (88) subfield shall be coded as defined in 4.3.8.4.2.2.3.10.

Note. — Structure of MV for a coordination reply:

33	37	41	53	55	59	60	61	62	63	87	88
VDS1 = 3	VDS2 = 0	ARA	RMF	ARA	RAT	VMTE	HMTE	TTI.	TID	VRAT	HRAT
36	40	52	54	58	59	60	61	62	86	87	88

Rationale

The coordination reply is a message sent on 1,090 MHz in response to a TCAS resolution message by another equipped aircraft. Mode S ground radar request during an RA and a short time after, for the purpose of ground monitoring. A new RA report format is needed to take into account horizontal RAs in ACAS III and add the capability to identify a second threat.

…

4.3.8.4.2.7 *For ACAS Xa or ACAS III compliant systems: Extended squitter ME field for use in air-to-air coordination.* This 56-bit (33-88) field shall be used for air-to-air coordination involving ADS-B only equipped intruders (intruders that cannot receive a discrete 1030 MHz resolution message).

…

4.3.8.4.2.7.2.3.3 Bits (44-54) shall not be used by the ACAS X air-to-air coordination process ~~but are reserved for future use~~.

4.3.8.4.2.7.2.3.4 *DAA (detect and avoid).* This 2-bit (55-56) subfield shall be used as defined below:

00 No ~~DAA~~RWC capability or no capability of ~~DAA system~~RWC function to receive ~~CA coordination information~~TCAS Resolution Messages or ADS-B OCMs
01 Aircraft has ~~a DAA system~~an RWC function capable of receiving TCAS resolution messages and ADS-B OCMs
10 Aircraft has ~~a DAA system~~an RWC function capable of receiving only ADS-B OCMs
11 Not defined

Note 1. — DAA encompasses an RWC function and a CA function. The DAA bits indicate whether and what type of coordination information needs to be provided to the aircraft so that the ~~DAA system~~RWC function of the threat aircraft can listen and provide guidance that is interoperable with ACAS. These bits are independent of the CA Coordination capability bits, as aircraft with a DAA system may or may not have an ACAS. For more details of DAA bits, refer to EUROCAE/ED-264 or RTCA/DO-~~365~~382.

Note 2. — The type of coordination message transmitted, resolution message or ADS-B OCM, depends both on the receive capability of the DAA system and on the transmit capability of the ACAS. If the DAA system can receive both the resolution message and the OCM, an ACAS with 1030 MHz transmit capability is required to transmit the resolution message.

…

4.3.8.4.2.7.2.4.1 *Bits (57-58)*. This 2-bit (57-58) subfield shall be set to 0 ~~for ACAS X air-to-air coordination purposes~~.

4.3.8.4.2.7.2.4.2 *Bits (59-64) and Bit 72. ~~The bits (59-64) and bit 72 shall not be used by the ACAS X air-to-air coordination process~~*Bit (59) shall be set by the transponder when there is an active RA and Bit 72 shall be set by the transponder when there is an active RWC alert.

Note. — Bits (60-64) are not relevant for coordination.

4.3.8.4.2.7.2.4.3 *CCCB (collision avoidance coordination capability bits).* This 7-bit (65-71) subfield shall be used as defined below:

Vertical and horizontal (2 bits (65-66))

00	Vertical
01	Horizontal
10	Blended
11	~~Reserved~~Vertical only or Horizontal only per intruder

Aircraft CAS Type / Capability (3 bits (67-69))

000	~~Active ACAS (~~TCAS II or no CAS~~)~~
001	Active ~~ACAS~~CAS (except ~~all~~ TCAS II)
010	Active ~~ACAS~~CAS (except ~~all~~ TCAS II) with OCM transmit capability
011	~~Responsive ACAS~~ Active CAS of junior status
100	Passive ~~ACAS~~CAS with 1030 MHz resolution message receive capability
101	Passive ~~ACAS~~CAS with only OCM receive capability
110 to 111	Reserved

Reserved (2 bits (70-71))

00 to 11	~~Intended for unmanned aircraft systems~~Reserved for future use

~~*Note. — The two reserved bits marked 'Intended for unmanned aircraft systems use' are envisioned as a priority field to distinguish among users with different levels of capability or as directed by regulatory authorities.*~~

Rationale

The change is made for alignment with the MASPS on ACAS interoperability. It is already taken into account in the production of ACAS Xa equipment.

…

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 Gillham encoded, at least two independent sources shall be used and compared continuously in order to detect encoding errors.

Note. — International Commercial Air Transport aeroplanes cannot use Gillham encoded altitude sources as they have to equip with a data source that provides pressure-altitude information with a resolution of 7.62 m (25 ft), or better, in accordance to Annex 6 Part I, 6.20.2.

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

Rationale
A note is added to highlight the importance of compliance to Annex 6 requirement which forbids Gillham encoded altitude sources for international commercial air transport aeroplanes

4.3.9 ACAS equipment characteristics

4.3.9.1 *Interfaces.* As a minimum, the following input data shall be provided to the ACAS:

a) 24-bit aircraft address ~~code~~;

b) air-air ~~and ground-air~~ Mode S transmissions received by the Mode S transponder for use by ACAS (4.3.~~6.3~~11.2.2);

c) other data from the Mode S transponder for use by ACAS (e.g. own aircraft's Mode A identity data, own aircraft's ability to transmit OCMs) (4.3.11.2.2);

~~c) own aircraft's maximum cruising true airspeed capability (Chapter 3, 3.1.2.8.2.2);~~

d) pressure-altitude;

e) above ground level altitude (e.g. radio altitude);

f) operating mode control (e.g. standby, TA only, Surveillance Only, RWC/CA and TA/RA Mode);

Rationale
Correction of the list and addition of items linked to the ACAS X / DAA – OCMs, RWC/CA.

…

4.3.10 Monitoring

4.3.10.1 *Monitoring function.* ACAS shall continuously perform a monitoring function in order to provide a warning if any of the following conditions at least are satisfied:

a) there is no interrogation power limiting due to interference control (4.3.2.2.2) and the maximum radiated power is reduced to less than that necessary to satisfy the surveillance requirements specified in 4.3.2; or

b) any other failure in the equipment is detected which results in a reduced capability of providing ~~TAs~~caution level alerts or RAs; or

Rationale
ACAS III may use TAs that are defined in this annex but they also may use cautionary alerts which are not exactly issued in the same way as TAs. To allow such designs, the introduction of the notion of caution-level alert, of which TAs are particular cases, is necessary.

…

4.3.11.2.1 Data transfer from ACAS to its Mode S transponder:

a) The Mode S transponder shall receive from its ACAS RA information for transmission in an RA report (4.3.8.4.2.2.1, 4.3.8.4.2.2.2 and 4.3.8.4.2.2.3), ~~and~~ in a coordination reply (4.3.8.4.2.4.2), and to set the appropriate DR code in DF = 4, 5, 20, and 21 replies;

b) the Mode S transponder shall receive from its ACAS current sensitivity level for transmission in a sensitivity level report (4.3.8.4.2.5); and

c) the Mode S transponder shall receive from its ACAS capability information for transmission in a data link capability report (4.3.8.4.2.2.~~2~~4) and for transmission in the RI field of air-air downlink formats DF = 0 and ~~DF =~~ 16 (4.3.8.4.1.2)~~;~~ ~~and~~.

Note.— 1090ES ADS-B version 3 devices accept capability information for transmission in the ADS-B Aircraft Operational Status Message (4.3.8.4.2.7.2).

~~d) the Mode S transponder shall receive from its ACAS an indication that RAs are enabled or inhibited for transmission in the RI field of downlink formats 0 and 16.~~

Rationale
New references to the data from ACAS Xa compliant systems and the data from ACAS III systems were added in a). Last part of the sentence in a) was also added for exhaustivity.
Requirement d) was deleted because the piece of information "RA enabled or inhibited" is part of the capability information addressed in c).

4.3.11.2.2 Data transfer from Mode S transponder to its ACAS:

~~a) For TCAS Version 7.1 compliant systems: The Mode S transponder shall transfer to its ACAS received sensitivity level control commands (4.3.8.4.2.1.1) transmitted by Mode S stations;~~

Rationale
Regarding the transfer of SLC commands, that capability was taken out of the most recent version of the transponder to avoid letting any entity on the ground to have control over the sensitivity level of the ACAS. So while transponders with subnetwork version 5 and lower do contain this function, it is no longer thought as a minimum requirement for any version of the system (i.e. if there was a subnetwork version 5 transponder that did not send SLC, that would be acceptable).

~~b~~a) the Mode S transponder shall transfer to its ACAS received ACAS broadcast messages (4.3.8.4.2.3.3) transmitted by other ACASs;

~~c~~b) the Mode S transponder shall transfer to its ACAS received resolution messages (4.3.8.4.2.3.2) transmitted by other ACASs for air-air coordination purposes; and

~~d~~c) the Mode S transponder shall transfer to its ACAS own aircraft's Mode A identity data for transmission in an RA broadcast (4.3.8.4.2.3.4.1.5).

d) the Mode S transponder shall transfer to its ACAS the 24-bit aircraft address.

e) the Mode S transponder shall transfer to its ACAS the pressure altitude from the source that is the basis for own altitude in Mode C and Mode S replies.

f) the Mode S transponder shall transfer to its ACAS the quantization for pressure altitude (fine [10 feet or less] or coarse [more than 10 feet]).

g) the Mode S transponder of subnetwork version 6 or greater shall transfer to its ACAS own aircraft's ability to transmit OCMs.

h) the Mode S transponder shall transfer to its ACAS the Mode S subnetwork version.

Note.— Mode S transponders prior to subnetwork version 6 transfer to its ACAS received sensitivity level control commands (4.3.8.4.2.1.1) transmitted by Mode S stations.

Rationale

While added items from d) to f) are required to be transmitted in the existing ACAS II and ACAS III system, items g) and h) are required to be transmitted in the ACAS Xa and ACAS Xu. TCAS v7.1 does not need these information as it would not use them.

4.3.11.2.2.1 Mode S transponders used with ACAS III shall have the ability to provide pressure altitude data quantized to less than or equal to 1 foot.

Rationale

The reference ACAS III system, ACAS Xu, requires this accuracy level to perform nominally.

…

4.3.11.3.2.1 The ACAS Mode S transponder shall reply with a coordination reply to a coordination interrogation received from another ACAS if ~~and only if~~ the transponder is able to deliver the ACAS data content of the interrogation to its associated ACAS and the reply is not eliminated by reply rate limiting.

4.3.11.4 COMMUNICATION OF ACAS INFORMATION TO GROUND STATIONS

4.3.11.4.1 *RA reports to Mode S ground stations.* During the period of an RA and for 18±1 s following the end of the RA, the ACAS Mode S transponder shall indicate that it has an RA report by setting the appropriate DR field code in replies to a Mode S sensor as specified in 4.3.8.4.1.1. The RA report shall include the MB field as specified in 4.3.8.4.2.2.1, 4.3.8.4.2.2.2 and 4.3.8.4.2.2.3. The RA report shall describe the most recent RA that existed during the preceding 18±1 s period.

Rationale

New references to add the data from ACAS Xa compliant systems and the data from ACAS III systems.

…

4.3.12 Indications to the flight crew

~~4.3.12.1 CORRECTIVE AND PREVENTIVE RAS~~

~~**Recommendation.**— *Indications to the flight crew should distinguish between preventive and corrective RAs.*~~

~~4.3.12.2 ALTITUDE CROSSING RAS~~

~~**Recommendation.**— *If ACAS generates an altitude crossing RA, a specific indication should be given to the flight crew that it is crossing.*~~

4.3.12.1 *Corrective and preventive RAs.* Visual and/or aural indications to the flight crew shall distinguish between the following RA types and the dimension (horizontal / vertical) of intended Resolution Advisory:

a) Horizontal RAs, vertical RAs and combined horizontal and vertical RAs;

b) RAs requiring a change in vertical or horizontal path and those RAs that do not require a change in flight path;

c) Altitude-crossing RAs and non-altitude-crossing RAs; and

d) RAs that change sense in one or more dimensions and those that do not change sense in one or more dimensions.

Note 1.— Specific guidance for ACAS II RA indications is provided in RTCA DO-185B/ED-143 and RTCA DO-385/ED-

256.

Note 2.— Specific guidance for ACAS III RA indications is provided in RTCA DO-365B.

4.3.12.2 Visual indications to the flight crew shall be located in the field of view of all operating pilots.

Rationale

Pilot awareness of the different types of RA is seen as essential for good responses to alerts, so it is proposed to raise the recommendations to requirements and to add other types of RAs between which the indications must help the pilots to distinguish

…

4.4 PERFORMANCE OF THE ACAS ~~II~~ COLLISION AVOIDANCE LOGIC

Note ~~1~~.— Caution is to be observed when considering potential improvements to ACAS since changes may affect more than one aspect of the system performance. It is essential that alternative designs would not degrade the performances of other designs and that such compatibility is demonstrated with a high degree of confidence. ~~The performance specified in Section 4.4 is based on the performance achieved by TCAS Version 7.1 compliant systems.~~

~~*Note 2.— The performance of ACAS X compliant systems is improved compared to the performance of TCAS Version 7.1 compliant systems. For more information, refer to the Airborne Collision Avoidance System (ACAS) Manual* (Doc 9863).~~

Rationale

Section 4.4 is now subdivided into General provisions (for ACAS II and ACAS III) and two specific subsections with provisions for ACAS II and for ACAS III.
The deleted text in the notes is specific to ACAS II and will be moved under the ACAS II subsection.

4.4.1 General provisions

4.4.1.1 COMPATIBILITY BETWEEN DIFFERENT COLLISION AVOIDANCE LOGIC DESIGNS

When considering alternative collision avoidance logic designs, certification authorities shall verify that:

a) the performances of the alternative design are acceptable in encounters involving ACAS units that use existing designs; and

b) the performances of the existing designs are not degraded by the use of the alternative design.

Note 1.— To verify the compatibility between different collision avoidance logic designs, the conditions described in 4.4.2.2.7 b) are the most severe that can be anticipated in this respect.

Note 2.— For more guidance on compatibility between different collision avoidance logic designs, refer to ACAS Manual. In addition, for more details about the evaluation of this compatibility, refer to EUROCAE ED-264 / RTCA DO-382 - Minimum Aviation System Performance Standards (MASPS) for the Interoperability of Airborne Collision Avoidance Systems

4.4.1.2 RELATIVE VALUE OF CONFLICTING OBJECTIVES

Recommendation.— *The collision avoidance logic should be such as to reduce as much as practicable the risk of collision (as defined in 4.4.2.3) and limit as much as practicable the disruption to ATM (as defined in 4.4.2.4).*

Rationale

The general provisions are former sections 4.4.2.8 and 4.4.5. The recommendation in 4.4.2.8 is elevated to a requirement, in light of the system validation experience and the availability of guidance for the evaluation of ACAS interoperability performance (a note is added to reference this guidance).

4.4.2 Performance of the ACAS II collision avoidance logic

Note.—The performance specified for ACAS II is based on the performance achieved by TCAS Version 7.1 compliant systems. The performance of ACAS X compliant systems is improved compared to the performance of TCAS Version 7.1 compliant systems. For more information, refer to the Airborne Collision Avoidance System (ACAS) Manual (Doc 9863).

~~4.4.1 Definitions relating to the performance of the collision avoidance logic~~

4.4.2.1 DEFINITIONS RELATING TO THE PERFORMANCE OF THE COLLISION AVOIDANCE LOGIC

…

~~***Encounter.*** For the purposes of defining the performance of the collision avoidance logic, an encounter consists of two simulated aircraft trajectories. The horizontal coordinates of the aircraft represent the actual position of the aircraft but the vertical coordinate represents an altimeter measurement of altitude.~~

…

Origin: SP/5	**Rationale:** The encounter definition has been relocated under Chapter 1, in the common definitions for part 1 and part 2) as it is also used in part 2.

[Note to the editor: all sections between the section above and the section below must be shifted by one title level, with “.2” inserted after “4.4” in the numbering.]

…

~~4.4.2.8 COMPATIBILITY BETWEEN DIFFERENT COLLISION AVOIDANCE LOGIC DESIGNS~~

~~**Recommendation.**— *When considering alternative collision avoidance logic designs, certification authorities should verify that:*~~

~~*a) the performances of the alternative design are acceptable in encounters involving ACAS units that use existing designs; and*~~

~~*b) the performances of the existing designs are not degraded by the use of the alternative design.*~~

~~*Note.— To address the compatibility between different collision avoidance logic designs, the conditions described in 4.4.2.7 b) are the most severe that can be anticipated in this respect.*~~

[Note to the editor: all sections between the section above and the section below must be shifted by one title level, with “.2” inserted after “4.4” in the numbering.]

…

~~4.4.5 Relative value of conflicting objectives~~

~~**Recommendation.**— *The collision avoidance logic should be such as to reduce as much as practicable the risk of collision (measured as defined in 4.4.3) and limit as much as practicable the disruption to ATM (measured as defined in 4.4.4).*~~

4.4.3 Performance of the ACAS III collision avoidance logic

4.4.3.1 GENERAL PRINCIPLE

ACAS III performance in the areas of safety and ATM disruption shall be evaluated through large-scale encounter simulation using validated encounter sets, surveillance models, pilot models and metrics, with the very high level of rigor associated with ACAS design, development, implementation, and testing.

Note 1. — The performance of ACAS Xu compliant systems is improved compared to the performance of TCAS Version 7.1 compliant systems.

Note 2.— The definitions in chapter 1, the conditions, surveillance models, pilot models and scenarios in 4.4.2.1, and the metrics in 4.4.2.3 and 4.4.2.4 are valid for ACAS III performance evaluation but need to be supplemented for ADS-B and non-cooperative surveillance and for horizontal advisories. The encounter model in 4.4.2.2 is not sufficient for ACAS III performance evaluations.

Note 3.— RTCA DO-386 / EUROCAE ED-275 Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) complies with this provision and can be used as a reference regarding the types of encounter sets and diversity of metrics to be considered.

4.4.3.2 REDUCTION IN THE RISK OF COLLISION

4.4.3.2.1 Under the appropriate validation conditions introduced in 4.4.3.1, the reduction target in 4.4.2.3 shall apply to the ACAS III collision avoidance logic, when encountering cooperative intruders.

4.4.3.2.2 Under the appropriate validation conditions introduced in 4.4.3.1, the reduction target in Part 2, 11.1.3, second line of the table, shall apply to the ACAS III collision avoidance logic, when encountering non-cooperative intruders.

Rationale

As developing a full framework for the evaluation of the ACAS III CA logic has been considered to be impractical, the new sections establishes a general requirement about the validation of ACAS III performance and endorses the minimum performance for the main safety metric, reduction in the risk of collision, that is established in 4.4.2 for ACAS II against cooperative intruders and in part 2 for the CA function against non-cooperative intruders.

4.5 ACAS USE OF EXTENDED SQUITTER

4.5.1 ACAS hybrid surveillance using extended squitter position data

Note.— Surveillance protocols defined in this section are for ACAS hybrid surveillance, and surveillance protocols for ACAS not equipped for hybrid surveillance are defined in 4.3.7.1.

4.5.1.1 DEFINITIONS

…

Passive surveillance. The process of tracking another aircraft ~~without interrogating it, by using the other aircraft’s extended squitters. ACAS uses the information obtained via 1090 MHz extended squitter to monitor the need for active surveillance, but not for any other purpose. Passive surveillance applies to both hybrid and extended hybrid surveillance~~by using the other aircraft’s ADS-B data

Origin: SP/5	**Rationale:** Generalization of the definition, which gave the impression that passive surveillance only covers hybrid and extended hybrid surveillance, while it is also used in a more general sense elsewhere.

~~***Validation.*** The process of verifying the relative position of an intruder using passive information via 1 090 MHz extended squitter by comparing it to the relative position obtained by ACAS active interrogation.~~

Origin: SP/5	**Rationale:** The definition has been relocated in Chapter 1 because validation is used in other contexts than just hybrid surveillance

…

4.5.1.4 *Near threat*. An intruder shall be tracked under active surveillance if it is a near threat, as determined by separate tests on the range and altitude of the aircraft. These tests shall be such that an intruder is considered a near threat before it becomes a potential threat, and thus triggers a traffic advisory as described in 4.3.3. These tests shall be performed once per second. ~~All near threats, potential threats and threats shall be tracked using active surveillance.~~

Rationale

The sentence is redundant with the same sentence in 4.5.1.6.1.

Origin SP/5	**Rationale for Initial Proposal 2** This proposal develops ACAS III provisions as well as provisions on the performance of airborne primary surveillance radar for optional use in ACAS. The recently standardized ACAS Xu includes a collision avoidance function with horizontal advisories. Other systems with collision avoidance RAs in the horizontal dimension are also being developed. The ACAS III type of ACAS is the relevant vehicle to standardize such kinds of RAs. Progress in the airborne surveillance of non-cooperative aircraft have occurred and ACAS could accommodate such a sensor.

INITIAL PROPOSAL 3

CHAPTER 7. TECHNICAL REQUIREMENTS FOR AIRBORNE SURVEILLANCE APPLICATIONS

Note 1.— Airborne surveillance applications (ASA) are based on aircraft receiving and using ADS-B message information transmitted by other aircraft/vehicles or ground stations. The capability of an aircraft to receive and use ADS-B/TIS-B message information is referred to as ADS-B~~/TIS-B~~ IN.

Note 2.— ~~Initial a~~Airborne surveillance applications use ADS-B messages on 1 090 MHz extended squitter to provide airborne traffic situational awareness ~~(ATSA)~~ and other capabilities supporting flight operations~~are expected to "In-trail procedures" and "Enhanced v~~.

Note 3.— It is recognized that ADS-B messages can be received across a variety of links other than 1 090 MHz extended squitter; including UAT and VDL4. These messages can be treated the same regardless of the link received for ASA.

Note ~~3~~4.— Detailed ~~description of aforementioned applications~~ requirements descriptions for ASA can be found in RTCA DO-~~289~~317C / EUROCAE ED-194B and RTCA DO-~~312~~361A / EUROCAE ED-236A.

…

7.1.1.2 TRACKING THE REFERENCE AIRCRAFT

7.1.1.2.1 The system shall support a function to monitor the movements and behaviour of each reference aircraft relevant to the application.

7.1.1.2.2 The system shall support a function to monitor qualification of each reference aircraft for the ASA in use.

Note.— The qualification of each reference aircraft is typically achieved by system checks of the ADS-B quality indicators of each reference aircraft as compared to the requirements for the ASA in use. See RTCA DO-317C / EUROCAE ED-194B for further details.

7.1.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

7.1.1.3.1 ~~**Recommendation.**— *The system should support a computational function to predict the future position of a reference aircraft beyond simple extrapolation.*~~

~~*Note.— It is anticipated that this function will be required for future applications*~~Predicting an estimated future position and/or trajectory of the reference aircraft shall be performed as specified by each ASA.

7.1.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

Calculations involving both own aircraft and traffic data shall be performed as specified by each ASA.

7.1.2 Displaying traffic information

Note.— Provisions ~~contained~~ 7.1.2.1 thru 7.1.2.3 in this section apply to cases wherein tracks generated by ACAS and by reception of ADS-B/TIS-B ~~IN~~ messages are shown on a single display.

7.1.2.1 The system shall display only one track for each distinct aircraft on a given display.

Note.— This is to ensure that tracks established by ACAS and ADS-B~~/TIS-B~~ IN are properly correlated and mutually validated before being displayed.

7.1.2.2 Where a track generated by ADS-B~~/TIS-B~~ IN and a track generated by ACAS have been determined to belong to the same aircraft, the track generated by ADS-B~~/TIS~~-B IN shall be displayed.

Note.— At close distances, it is possible that the track generated by ACAS provides better accuracy than the track generated by ADS-B~~/TIS-B~~ IN. The requirement above ensures the continuity of the display.

7.1.2.3 The display of the tracks shall comply with the requirements of ACAS traffic display.

Note.— Section 4.3 addresses colour coding and readability of the display.

7.1.2.4 The system shall have a means to select the best source of surveillance information when multiple sources are available.

7.1.2.5 A reference aircraft in active use by an ASA shall be clearly distinguishable as such.

7.1.2.6 The system shall prioritize reference aircraft for surveillance tracking, application processing, and display such that ACAS alerting, aircraft in use by an ASA, aircraft selected by the flight crew, and proximate aircraft are higher priority than other airborne and surface tracks.

7.1.2.7 The system shall display a reference aircraft's directionality.

7.1.2.8 When requested by the flight crew, the system shall display a reference aircraft's identification and ground speed.

7.1.2.9 If situational awareness on surface traffic is implemented, the system shall support display of an underlying airport surface map.

Note.— *For more details on the implementation of situational awareness on surface traffic, refer to section 2.2.4.2 of DO-317C/ED194B.*

7.1.2.10 Displays providing annunciations that require immediate flight crew awareness shall be located in the field of view of all operating pilots.

7.1.2.11 **Recommendation. —** *ASA information should be integrated into existing flight deck displays.*

7.1.3 Use of calculated information

7.1.3.1 The system shall interface with the audio alert system for ASAs with audio alerts.

~~7.1.3.2 The system shall include controls and flight crew entry of information as appropriate to each ASA.~~

~~*Note.— This includes controls and display interface for ACAS Xo.*~~

7.1.3.2 The system shall provide an advisory alert if the reference aircraft in active use by an ASA ceases to qualify for that application.

7.1.3.3 The system shall determine and display the status of implemented ASAs.

7.1.4 Flight Crew interfaces

7.1.4.1 The system shall include controls and a means of flight crew entry of information as appropriate to each ASA.

Note.— This includes controls and display interface for ACAS Xo.

7.1.4.2 Aircraft installations shall allow all operating pilots to utilize the equipment.

7.2 ADDITIONAL REQUIREMENTS FOR VSA AVIONICS FUNCTIONS

Note.— These requirements are in addition to those listed in 7.1 (and subsections) and apply only if the Visual Separation on Approach (VSA) avionics functions are implemented.

7.2.1 Traffic data functions

7.2.1.1 IDENTIFYING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.2.1.2 TRACKING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.2.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.2.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

7.2.1.4.1 The system shall be capable of calculating a reference aircraft's range and differential ground speed relative to own aircraft.

7.2.2 Displaying traffic information

7.2.2.1 When requested by the flight crew, the system shall display a reference aircraft's horizontal velocity vector.

7.2.3 Use of calculated information

7.2.3.1 When requested by the flight crew, the system shall display a reference aircraft's range and differential ground speed relative to own aircraft.

7.3 ADDITIONAL REQUIREMENTS FOR ADS-B Traffic Awareness System (ATAS) AVIONICS FUNCTIONS

Note 1.— These requirements are in addition to those listed in 7.1 (and subsections) and apply only if the ATAS avionics functions are implemented.

Note 2.— ATAS may be installed without a traffic display. In such installations, the general display requirements in 7.1.2 do not apply and all user interface functionality is to be provided via an annunciator panel or individual lamps and controls.

Note 3.— ATAS is not acceptable to be integrated with ACAS X.

7.3.1 Traffic data functions

7.3.1.1 IDENTIFYING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.3.1.2 TRACKING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.3.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

7.3.1.3.1 The system shall support a computational function to predict the future position of a reference aircraft by extrapolation of ADS-B message data.

7.3.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

7.3.1.4.1 The system shall calculate potential conflicts between own aircraft and proximate aircraft, based on ADS-B reports and extrapolation.

7.3.2 Displaying traffic information

Note.— No additional requirements are added in this subsection.

7.3.3 Use of calculated information

7.3.3.1 The system shall give an alert when a potential conflict has been identified with a proximate aircraft.

7.3.3.2 The system shall provide a means to prioritize concurrent conflict alerts.

Note.— If ATAS and TCAS II are installed on the same aircraft, TCAS II alerts have priority.

7.3.3.3 The system shall provide the flight crew a means to acknowledge or suppress an aural annunciation that contains reference aircraft position.

7.4 ADDITIONAL REQUIREMENTS FOR In-Trail Procedures (ITP) AVIONICS FUNCTIONS

Note 1.— These requirements are in addition to those listed in 7.1 (and subsections) and apply only if ITP avionics functions are implemented.

Note 2.— TIS-B messages are not acceptable for use by ITP avionics functions.

7.4.1 Traffic data functions

7.4.1.1 IDENTIFYING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.4.1.2 TRACKING THE REFERENCE AIRCRAFT

7.4.1.2.1 The system shall validate the ADS-B position of the reference aircraft with ACAS surveillance data.

7.4.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.4.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

7.4.1.4.1 The system shall calculate whether the reference aircraft can be used for the ITP application by comparing the relative position and velocities of the reference aircraft and own aircraft.

7.4.1.4.2 The system shall calculate the distance between own aircraft, the reference aircraft, and a common point based on own aircraft heading or true track angle (when available).

Note.— If own aircraft and the reference aircraft are on intersecting paths, the common point is the point of intersection. Otherwise the common point is the reference aircraft's position as projected on to own aircraft's path. Own aircraft's true track angle is to be used if it is available to determine own aircraft's path.

7.4.2 Displaying traffic information

Note.— No additional requirements are added in this subsection.

7.4.3 Use of calculated information

7.4.3.1 The system shall provide the flight crew a means to select and display the following items:\

a) the qualification of the reference aircraft for ITP;

b) distance relative to the common point;, and

c) indication of whether the reference aircraft is ahead or behind.

7.5 ADDITIONAL REQUIREMENTS FOR CDTI-Assisted Visual Separation (CAVS) AVIONICS FUNCTIONS

Note 1.— These requirements are in addition to those listed in 7.1 (and subsections) and apply only if the CAVS avionics functions are implemented.

Note 2.— TIS-B messages are not acceptable for use by CAVS avionics functions.

7.5.1 Traffic data functions

7.5.1.1 IDENTIFYING THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.5.1.2 TRACKING THE REFERENCE AIRCRAFT

7.5.1.2.1 The system shall validate the ADS-B position of the reference aircraft with ACAS surveillance data.

7.5.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

Note.— No additional requirements are added in this subsection.

7.5.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

7.5.1.4.1 The system shall calculate the reference aircraft’s range and differential groundspeed relative to own aircraft.

7.5.2 Displaying traffic information

Note.— No additional requirements are added in this subsection.

7.5.3 Use of calculated information

7.5.3.1 The system shall provide the flight crew a means to select and display the differential ground speed and the reference aircraft’s range to own aircraft.

7.5.3.2 The system shall aurally and visually alert the flight crew when the range between the reference aircraft and own aircraft is less than the range for which the equipment is qualified to perform CAVS, based on traffic surveillance quality.

7.5.3.3 The system shall visually alert the flight crew when the range between the reference aircraft and own aircraft is less than an advisory value adjustable by the flight crew.

7.6 ADDITIONAL REQUIREMENTS FOR Flight-deck Interval Management (FIM) AVIONICS FUNCTIONS

Note 1.— These requirements are in addition to those listed in 7.1 (and subsections) and would apply only if the FIM avionics functions are implemented. Detailed descriptions can be found in RTCA DO-361A / EUROCAE ED-236A.

Note 2.— TIS-B messages are not acceptable for use by FIM avionics functions.

7.6.1 Traffic data functions

7.6.1.1 IDENTIFYING THE REFERENCE AIRCRAFT

7.6.1.1.1 The system shall support a function to request information on a specific reference aircraft, identified by the flight crew, from the ADS-B receiver.

7.6.1.1.2 The system shall be integrated with an ADS-B receiver capable of supporting long range acquisition of reference aircraft.

7.6.1.1.3 The system shall, upon initiating an IM operation relative to a reference aircraft, provide defined FIM data to the transponder.

7.6.1.2 TRACKING THE REFERENCE AIRCRAFT

7.6.1.2.1 The system shall validate the ADS-B position of the reference aircraft with ACAS surveillance data.

7.6.1.3 TRAJECTORY OF THE REFERENCE AIRCRAFT

7.6.1.3.1 The system shall support a computational function to generate a predicted trajectory for a reference aircraft, including an airspeed profile, vertical profile, and horizontal path, based on reference aircraft state, environmental data, and navigational procedures.

7.6.1.3.2 The system shall monitor the reference aircraft's position relative to its predicted trajectory.

7.6.1.3.3 The system shall be capable of determining if a predicted trajectory cannot be calculated given the available information.

7.6.1.4 CALCULATIONS BASED ON TRAFFIC DATA RELATIVE TO OWN AIRCRAFT

7.6.1.4.1 The system shall support a computational function capable of generating speed guidance for own aircraft in order to achieve a relative spacing objective, input by the flight crew as a time or distance, at a specific point on own aircraft's path, as input by the flight crew.

7.6.1.4.2 The system shall be capable of determining if achieving a relative spacing objective at a specific point on own aircraft's path is feasible (or not) based on own aircraft's expected navigation and the predicted relative spacing at the specific point.

7.6.1.4.3 The system shall support a computational function capable of calculating the current relative spacing, in time or distance, based on a reference aircraft's current position as projected on own aircraft's path.

7.6.1.4.4 The system shall support a computational function capable of generating speed guidance for own aircraft in order to capture and/or maintain a relative spacing objective, input by the flight crew as a time or distance, based on a reference aircraft's current position as projected on own aircraft's path.

7.6.1.4.5 The system shall limit speed guidance for own aircraft to follow airspace restrictions, procedural speed constraints required for safety, and to remain within a specified margin around own aircraft's expected, nominal airspeed profile.

7.6.2 Displaying traffic information

7.6.2.1 The system shall be capable of displaying a reference aircraft's route information, as input, as well as any other information input by the flight crew to support the relative spacing operation.

Note.— This would include the type of spacing operation, the spacing objective, any special points (e.g. an achieve-by point or planned termination point), and meteorological forecast data.

7.6.3 Use of calculated information

7.6.3.1 The system shall notify the flight crew if insufficient or invalid information has been provided to support the spacing operation specified.

Note.— Based on the spacing operation and route information specified, the equipment may need to calculate spacing objectives and points of reference. In some instances, depending on the information provided, these may not be calculable.

7.6.3.2 The system shall graphically display any input or calculated points relevant to the spacing operation.

7.6.3.3 The system shall notify the flight crew if a relative spacing objective is determined to be infeasible.

7.6.3.4 The system shall display speed guidance for own aircraft such that it, and any change, is easily observable.

7.6.3.5 The system shall display speed guidance for own aircraft in a manner consistent with the current cockpit mode of operation.

7.6.3.6 The system shall provide visual and aural notification to the flight crew if speed guidance for own aircraft has not been complied with in a timely manner.

7.6.3.7 The system shall notify the flight crew if the reference aircraft is not following the trajectory that the system has predicted for it.

Origin	**Rationale for Initial Proposal 2**
SP/5	This proposal provides a proposed revision to Chapter 7 of Annex 10 Volume IV, which specifies technical requirements for airborne surveillance utilizing ADS-B IN. ADS-B data can provide substantial benefit when integrated into the cockpit. The proposed revision includes a clarification of requirements for situational awareness and new requirements supporting a range of applications. Beyond enhanced situational awareness for flight crews on surrounding traffic, instead of specifying technical specifications in detail, this proposal specify minimum functional requirements for the use of currently available and new ADS-B IN capabilities and avionics functions, including Flight-deck Interval Management (FIM), to support various Airborne Surveillance Applications.

— END —