CIVIL AVIATION ACT
(Cap. 71:00)

CIVIL AVIATION (SURVEILLANCE AND COLLISION AVOIDANCE SYSTEM) REGULATIONS, 2022
(Published on 13th June, 2022)

ARRANGEMENT OF REGULATIONS

PART V — *Mode S Extended Squitter*

IN EXERCISE of the powers conferred on the Minister of Transport and Public Works by section 89 (1) of the Civil Aviation Act, and on the recommendation of the Civil Aviation Authority, the following Regulations are hereby made —

Citation　　　　　1. These Regulations may be cited as the Civil Aviation (Surveillance and Collision Avoidance Systems) Regulations, 2022.

Interpretation　　2. In these Regulations unless the context otherwise requires —

"Airborne Collision Avoidance System (ACAS)" means an aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders;

"ACAS I" means an ACAS which provides information an aid to "see and avoid" action but does not include the capability for generating resolution advisories (RAs);

"ACAS II" means an ACAS which provides vertical resolution advisories (RAs) in addition to traffic advisories (TAs);

"ACAS III" means an ACAS which provides vertical and horizontal resolution advisories (RAs) in addition to traffic advisories (TAs);

"ACAS broadcast" means a long Mode S air-air surveillance interrogation (UF = 16) with the broadcast address;

"active RAC (Resolution Advisory Compliments)" means an RAC currently constrains the selection of the RA, RACs that have been received within the last six seconds and have not been explicitly cancelled are active;

"active surveillance" means the process of tracking an intruder by using the information gained from the replies to own ACAS interrogations;

"aircraft address" means a unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance;

"air navigation services" means one or more of the following services provided for air navigation —

    (*a*) air traffic services;

    (*b*) Instrument Flight Procedure Design (IFPD) services;

    (*c*) Aeronautical Information services (AIS);

    (*d*) aeronautical cartographic services;

    (*e*) aeronautical telecommunication services; or

    (*f*) search and rescue services;

"Air Navigation Services Provider (ANSP)" means an entity established for the purpose of providing one or more of the air navigation services as defined in these Regulations;

"altitude crossing RA" means a resolution advisory is altitude crossing if own ACAS aircraft is currently at least 30m (100 ft) below or above the threat aircraft for upward or downward sense advisories, respectively;

"approach angle" means the difference in the ground headings of the two aircraft at closest approach, with 180 degrees defined as head on and 0 degrees defined as parallel;

"Automatic Dependent Surveillance-Broadcast (ADS-B) OUT)" means a function on an aircraft or vehicle that periodically broadcasts its state vector (position and velocity) and other information derived from on-board systems in a format suitable for ADS-B IN capable receivers;

"Automatic Dependent Surveillance-Broadcast (ADS-B) IN)" means a function that receives surveillance data from ADS-BOUT data sources;

"Automatic Dependent Surveillance-Broadcast (ADS-B) IN)" means a function that receives surveillance data from ADS-BOUT data sources;

"climb RA" means a positive RA recommending a climb but not an increased climb;

"closest approach" means the occurrence of minimum range between own ACAS aircraft and the intruder. A range at closest approach is the smallest range between the two aircraft and time of closest approach is the time at which this occurs;

"collision avoidance logic" means the sub-system or part of ACAS that analyses data relating to an intruder and own aircraft, decides whether advisories are appropriate and, if so, generates the advisories, and it includes the following functions —

    (*a*) range and altitude tracking;

    (*b*) threat detection and RA generation; and

    (*c*) it excludes surveillance;

"coordination" means the process by which two ACAS-equipped aircraft select compatible Resolution Advisories (RAs) by the exchange of Resolution Advisory Complements (RACs);

"coordination interrogation" means a Mode S Interrogation (uplink transmission) radiated by ACAS II or III and containing a resolution message;

"coordination reply" means 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;

"corrective RA" means a Resolution Advisory (RA) that advises the pilot to deviate from the current flight path;

"crossing encounter" means an encounter in which the altitude separation of the two aircraft exceeds 100 ft at the beginning and at the end of the encounter window, and the relative vertical position of two aircraft at the end of the encounter window is reversed from that at the beginning of the encounter window;

"cycle" means one complete pass through the sequence of functions executed by ACAS II or ACAS III, nominally once a second;

"descend RA" means a positive RA recommending a descent but not an increased descent;

"established track" means a track generated by ACAS air-air surveillance that is treated as the track of an actual aircraft;

"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;

"encounter class" means encounters classified according to whether the aircraft are transitioning at the beginning and end of the encounter window, and whether or not the encounter is crossing;

"encounter window" means the time interval [tca − 40 s, tca + 10 s];

"extended hybrid surveillance" means the process of using qualified ADS-B airborne position messages via 1 090 MHz extended squitter without validating 1 090 extended squitter data for the track by ACAS active interrogations;

"Horizontal Miss Distance (HMD)" means the minimum horizontal separation observed in an encounter;

"human factors principles" means principles which apply to design, certification, training, operations and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance;

"hybrid surveillance" means the process of using a combination of active surveillance and passive surveillance with validated data to update an ACAS track in order to preserve ACAS independence;

"increased rate RA" means an RA with a strength that recommends increasing the altitude rate to a value exceeding that recommended by a previous climb or descend RA;

"intruder" means an SSR transponder-equipped aircraft within the surveillance range of ACAS for which ACAS has an established track;

"MU" means a designator Message, Airborne Collision Avoidance System in the message field or in short MU field;

"Multilateration (MLAT) System" means 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;

"original trajectory" means the original trajectory of an ACAS-equipped aircraft followed by the aircraft in the same encounter when it was not ACAS equipped;

"original rate" means the original rate of an ACAS-equipped aircraft at any time is its altitude rate at the same time when it followed the original trajectory;

"own aircraft" means an aircraft —
  (*a*) fitted with an ACAS that is the subject of the discourse;
  (*b*) which an ACAS is to protect against possible collisions; and
  (*c*) which may enter a maneuver in response to an ACAS indication;

"passive surveillance" means the process of tracking another aircraft without interrogating it, by using the other aircraft's extended squitters (ACAS uses the information obtained via 1 090 MHz extended squitter to monitor the need for active surveillance only. Passive surveillance applies to both hybrid and extended hybrid surveillance);

"positive RA" means a Resolution Advisory that advises the pilot either to climb or to descend (applies to ACAS II);

"potential threat" means an intruder deserving special attention either because of its 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, and the warning time provided against a potential threat is sufficiently small that a Traffic Advisory (TA) is justified but not so small that a RA would be justified;

"Radio Frequency (RF)" means a measured unit called hertz (Hz), which represent the number of cycles per second when a radio wave is transmitted from one point to the other;

"RA sense" means the sense of an ACAS II RA is "upward" if it requires climb or limitation of descent rate and "downward" if it requires descent or limitation of climb rate, and it can be both upward and downward simultaneously if it requires limitation of the vertical rate to a specified range;

"required rate" means for the standard pilot model, the required rate is that closest to the original rate consistent with the RA;

"Resolution Advisory (RA)" means an indication given to the flight crew recommending —
  (*a*) a maneuver intended to provide separation from all threats; or
  (*b*) a maneuver restriction intended to maintain existing separation;

"Resolution Advisory Complement (RAC)" means information provided by one ACAS to another via a Mode S interrogation in order to ensure complementary maneuvers by restricting the choice of maneuvers available to the ACAS receiving the RAC;

"Resolution Advisory Complements record (RAC record)" means a composite of all currently active vertical RACs (VRCs) and horizontal RACs (HRCs) that have been received by ACAS. This information is provided by one ACAS to another ACAS or to a Mode S ground station via a Mode S reply;

"reversed sense RA" means an RA that has had its sense reversed;

"Secondary Surveillance Radar (SSR)" means a surveillance radar system which uses transmitters/receivers (interrogators) and transponders;

"sensitivity level (S)" means an integer defining a set of parameters used by the Traffic Advisory 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;

"surveillance radar" means radar equipment used to determine the position of an aircraft in range and azimuth;

"threat" means an intruder deserving special attention either because of its 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, and the warning time provided against a threat is sufficiently small that an RA is justified;

"Time Difference of Arrival (TDOA)" means the difference in relative time that a transponder signal from the same aircraft (or ground vehicle) is received at different receivers;

"Traffic Advisory (TA)" means an indication given to the flight crew that a certain intruder is a potential threat;

"Traffic Information Service – Broadcast (TIS-B) IN)" means a surveillance function that receives and processes surveillance data from TIS-B OUT data sources;

"Traffic Information Service – Broadcast (TIS-B) OUT)" means a function on the ground that periodically broadcasts the surveillance information made available by ground sensors in a format suitable for TIS-B IN capable receivers;

"transitioning aircraft" means an aircraft having an average vertical rate with a magnitude exceeding 400 feet per minute (ft/min), measured over some period of interest;

"transponder occupancy" means a state of unavailability of the transponder from the time it detects an incoming signal that appears to cause some action or from the time of a self-initiated transmission, to the time that it is capable of replying to another interrogation;

"turn extent" means an aircraft's ground heading at the end of a turn minus its ground heading at the beginning of the turn;

"validation" means 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 Airborne Collision Avoidance System active interrogation;

"Vertical Miss Distance (VMD)" means the minimum vertical separation observed in encounter; and

"warning time" means the time interval between potential threat or threat detection and closest approach when neither aircraft accelerates.

Application   3. These Regulations shall apply to a person providing surveillance services within a designated air space and at an aerodrome.

PART II — *General requirements*

4. The minimum requirements for planning, installation, commissioning, training, operation and maintenance of the surveillance facility shall conform to these Regulations.

5. (1) A person who wishes to operate a surveillance facility or system shall apply in writing to the Authority for an approval of the surveillance facility or system.

(2) The Authority may approve surveillance facility or system in a designated airspace and aerodrome.

(3) A person shall not provide or operate a surveillance facility or system in the designated airspace or aerodrome unless the surveillance facility or system has been approved by the Authority.

(4) An Air Navigation Service Provider shall notify the Authority of his or her intention to procure, install, use, decommission, upgrade or relocate any surveillance facility in the designated airspace or aerodrome not less than 30 days prior to the date of procuring, installing, decommissioning, upgrading or relocating such surveillance system.

(5) The Authority may approve installation, use, decommissioning, upgrading or relocation of all surveillance facilities in the designated airspace and aerodromes.

6. (1) The Authority may carry out safety inspections and audits on a surveillance facility, document or record to determine compliance with these Regulations.

(2) An inspector of the Authority shall have unrestricted access to a facility, installation, record or document of an Air Navigation Service Provider to determine compliance with these Regulations and required procedures.

7. An Air Navigation Service Provider shall before establishing any surveillance equipment site, whether temporary or permanent obtain approval of the site from the Authority.

8. The following list classifies the type of facilities used for the provision of aeronautical surveillance service —

  (*a*) flight data processing facility;
  (*b*) flight information facility;
  (*c*) radar data processing facility;
  (*d*) primary surveillance radar facility;
  (*e*) secondary surveillance radar facility;
  (*f*) surface movement radar facility;
  (*g*) Multi-Lateration surveillance facility (Mlat);
  (*h*) precision runway monitor facility;
  (*i*) automatic dependent surveillance system facility;
  (*j*) uninterruptible and emergency power supply facility;
  (*k*) essential service in a building and in equipment shelter housing facility (electrical power supply, air-conditioning, and security facility); and
  (*l*) data recording facility.

9. (1) An Air Navigation Service Provider shall establish an overall operation and maintenance plan for surveillance system which shall meet the safety, operational requirement and performance specification of a surveillance facility.

(2) The operation and maintenance plan in subregulation (1) shall include —

  (*a*) a procedure for the periodic inspection and testing of each facility to verify that it meets the specified operational and performance specifications;

(*b*) details of flight test, such as the standards and procedures to be used and flight test interval, which shall be in compliance with guidelines in International Civil Aviation Organisation Doc 8071 or any other appropriate International Civil Authority Organisation document;

(*c*) the interval between periodic inspection and flight test and the basis for that interval, and when the interval is changed, the reasons for such change shall be documented;

(*d*) the operation and maintenance instructions for each facility;

(*e*) an analysis of the number of personnel required to operate and maintain each surveillance facility, taking into account the workload required;

(*f*) the corrective plan and procedures for each surveillance facility, including whether the repair of modules and components are undertaken in house or by equipment manufacturers; and

(*g*) the spare support plan for each facility.

(3) An Air Navigation Service Provider shall be responsible for the provision of surveillance service and facility, to ensure that the surveillance data necessary for the safe, regular and efficient operation of air navigation is accurate and available.

(4) An Air Navigation Service Provider shall establish and document performance measures to be achieved for each surveillance system in terms of the following parameters —

(*a*) availability;

(*b*) reliability;

(*c*) accuracy;

(*d*) availability

(*e*) integrity;

(*f*) Mean Time Between Failure (MTBF); and

(*g*) Mean Time to Repair (MTTF).

(5) The parameters in subregulation (4), shall be derived or measured from —

(*a*) the configuration of each service; or

(*b*) the known performance of each service.

(6) An Air Navigation Service Provider shall, describe in the operations manual the method used to calculate each of the values in subregulation (7).

(7) The integrity values or characteristics shall be given for each facility that forms part of the surveillance service.

(8) An Air Navigation Service Provider shall ensure a surveillance facility is connected to a power and a standby power supply, to ensure continuity of operation appropriate to the service being provided.

Protection of surveillance radio signals from reflectors or diffractors

10. (1) An Air Navigation Service Provider shall prevent any development near a radio site that may have a potential to reflect or diffract surveillance radio signals.

(2) An Air Navigation Service Provider shall ensure that the following radar do not reflect or diffract surveillance radio signals - -

(*a*) Primary Radar - Line of sight from the installation to surveillance areas or volume shall be maintained. No obstruction shall penetrate the volume above the radar platform for a distance of 4 600m from the installation or prevent line-of-sight from the installation to aircraft during the approach phase and movements on runways;

(*b*) Secondary Surveillance Radar – Line of sight from the installation to surveillance areas or volume shall be maintained to a distance of 15km. No obstruction shall penetrate the volume above the radar platform for a distance of 4 600m from the installation or prevent line-of-sight from the installation to aircraft during the approach phase and movements on runways;

(*c*) Surface Movement Radar - Line-of-sight shall be maintained at ground level from the radar to all areas within the aerodrome boundary where any movement of aircraft, personnel or vehicles can occur;

(*d*) Multi Lateration (MLat) - Line of sight from the installation to surveillance areas or volume shall be maintained. No obstruction shall penetrate the volume above the surveillance platform for a distance of 4 600m from the installation or prevent line-of-sight from the installation to aircraft during the approach phase and movements on runway; and

(*e*) Automatic Dependant Surveillance – Broadcast (ADS-B) Line of sight from the installation to surveillance areas or volume shall be maintained. No obstruction shall penetrate the volume above the Surveillance platform for a distance of 4 600m from the installation or prevent line-of-sight from the installation to aircraft during the approach phase and movements on runways.

(3) An Air Navigation Service Provider shall consult the Authority regarding the non-use of designs or certain materials considered to be reflective or that could cause attenuation of the signal, such as metal reinforced glass, metal cladding, chain-link fencing, on elevations facing the surveillance installations shall be undertaken.

11. An Air Navigation Service Provider shall establish a procedure for the periodic inspection and testing of a surveillance system, to verify that each facility meets the applicable operational requirements and performance specifications for that facility.

12. An Air Navigation Service Provider shall —

(*a*) establish a procedure for retention and release of surveillance data;

(*b*) retain recording of surveillance for a period of at least 30 days; and

(*c*) retain recordings that are pertinent to an accident or incident investigations for longer periods until it is evident that they will no longer be required.

13. (1) An Air Navigation Service Provider shall provide recording equipment capable of automatic recording and replaying of surveillance data from primary and secondary radar equipment or other surveillance systems used as an aid to air traffic service.

(2) A recording equipment shall provide a complete, identified, intelligible and accurate record of surveillance data to be recorded which may be used, in the event of an incident or in any investigation, by the designated Authority.

(3) A recorded surveillance data shall include targets, system settings, time, alerts, alarms and any information necessary for investigation play back.

(4) A replay equipment shall reconstruct the recorded data and shall, accurately reproduce all the features that were displayed, including display settings, at the relevant operational positions at the time of recording.

Secondary
Surveillance
Radar (SSR)
operations

14. When Secondary Surveillance Radar is installed and maintained in operation as an aid to air traffic service, it shall conform to the provisions specified in Schedule 1 of these Regulations, unless otherwise specified.

Commissioning
Requirements

15. (1) An Air Navigation Service Provider shall carry out a test flight during a system commissioning technical acceptance test.

(2) To assess performance, a test method shall comprise of the following stages —

(*a*) data collection and observations;

(*b*) data analysis; and

(*c*) comparison of results.

(3) A manufacture shall measure the following parameters prior to a test in subregulation (1), being carried out as part of planned maintenance —

(*a*) horizontal polar diagram;

(*b*) vertical polar diagram;

(*c*) antenna gain; and

(*d*) azimuth squint and skew, that is, distortion of beam shape (squint) or skew (direction) as function of frequency within the operating bandwidth of the antenna.

(4) The results from the measurements in subregulation (3), shall be made available to the user.

System
recording and
replay facilities

16. An Air Navigation Service Provider shall continuously record radar surveillance data supplied to the display system and establish procedures for retention and utilisation of the recordings for analysis.

Interrogation
modes (ground
-to-air)

17. (1) An Air Navigation Service Provider shall ensure that an interrogation of air traffic services is performed on the modes specified in paragraph 1.1.1.4.3 and 1.1.2, set out in Schedule 1 and each mode shall be used as follows —

(*a*) Mode A – to elicit transponder replies for identity and surveillance;

(*b*) Mode C – to elicit transponder replies for automatic pressure-altitude transmission and surveillance;

(*c*) Intermode —

(i) Mode A/C/S all-call: to elicit replies for surveillance of Mode A/C transponders and for the acquisition of Mode S transponders, and

(ii) Mode A/C-only all-call: to elicit replies for surveillance of Mode A/C transponders. Mode S transponders do not reply, and

(*d*) Mode S —

(i) Mode S – only all-call: to elicit replies for acquisition of Mode S transponders,

(ii) Broadcast: to transmit information to all Mode S transponders. No replies are elicited, and

(iii) Selective: for surveillance of, and communication with, individual Mode S transponders. For each interrogation, a reply is elicited only from the transponder uniquely addressed by the interrogation.

(2) The Authority shall coordinate with appropriate national and international authorities to ensure that implementation aspects of the SSR system which permits the SSR sytem's optimum use.

(3) The assignment of interrogator identifier codes in areas of overlapping coverage, across international boundaries of flight information regions, shall be the subject of regional air navigation agreements.

(4) The assignment of surveillance identifier codes in areas of overlapping coverage, shall be the subject of regional air navigation agreements.

(5) Mode A and Mode C interrogations shall, be provided by intermode interrogations which elicit Mode A and Mode C replies from Mode A/C transponder.

(6) In areas where improved aircraft identification is necessary to enhance the effectiveness of the air traffic control system, secondary surveillance radar ground facility having Mode S features shall include aircraft identification capability.

18. (1) A Side-lobe suppression shall be provided in accordance with paragraphs 1.1.1.4 and 1.1.1.5 set out in Schedule 1 on all Mode A, Mode C and inter-mode interrogations. Side-lobe suppression

(2) A Side-lobe suppression shall be provided in accordance with paragraph 1.1.2.1.5.2.1 set out in Schedule 1 on all Mode S-only all-call interrogations.

19. (1) A transponder shall respond to Mode A interrogations in accordance with paragraph 1.1.1.7.12.1 set out in the Schedule 1 and to Mode C interrogations in accordance with the paragraph 1.1.1.7.12.2. set out in Schedule 1. Transponder reply modes (air-to-ground)

(2) The pressure-altitude report contained in Mode S replies shall be as specified in paragraph 1.1.1.7.12.2. set out in Schedule 1.

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

(4) A transponder, regardless of the airspace in which it will be used, shall respond to Mode C interrogations with pressure-altitude information.

(5) The pressure-altitude information provided by Mode S transponder in response to selective interrogations of an aircraft equipped with 7.62 m (25 ft.) or better pressure-altitude sources, shall be reported in 7.62 m (25 ft) increments.

(6) A Mode A/C transponder shall report pressure-altitude encoded in the information pulses in Mode C replies.

(7) A Mode S transponder shall report pressure-altitude encoded in the information pulses in Mode C replies and in the AC field of Mode S replies.

(8) When a Mode S transponder is not receiving more pressure-altitude information from a source with a quantisation of 7.62 m (25 ft) or better increments, the reported value of the altitude shall be the value obtained by expressing the measured value of the uncorrected pressure-altitude of the aircraft in 30.48 m (100 ft) increments, and the Q bit shall be set to 0.

(9) A transponder used within airspace where the need for Mode S airborne capability has been determined, shall also respond to intermode and Mode S interrogations in accordance with the paragraph 1.1.2. set out in Schedule 1.

(10) The requirements for mandatory carriage of secondary surveillance radar Mode S transponder shall —

(*a*) be based on regional air navigation agreements; and

(*b*) specify the airspace and the airborne implementation timescales.

(11) The agreements indicated in subregulation (10) shall provide at least a notice of five years.

20. (1) A transponder shall be capable of generating 4096 reply codes conforming to the characteristics in accordance with paragraph 1.1.1.6.2. set out in Schedule 1. Mode A reply codes (information pulses)

(2) The Authority shall establish the procedures for the allotment of secondary surveillance radar code in conformity with regional air navigation agreements, considering other users of the system.

(3) The following Mode A codes shall be reserved for special purposes —

(a) Code 7700, to provide for recognition of an aircraft in an emergency;

(b) Code 7600, to provide for recognition of an aircraft with radio communication failure; and

(c) Code 7500, to provide for recognition of an aircraft which is being subjected to unlawful interference.

(4) Provisions shall be made in ground decoding equipment, to ensure immediate recognition of Mode A codes 7500, 7600 and 7700.

(5) A Mode A code 0000 shall be reserved for allocation subject to regional agreement, as a general-purpose code.

(6) A Mode A code 2000 shall be reserved to provide recognition of an aircraft which has not received any instructions from air traffic control units to operate the transponder.

Mode S airborne equipment capability

21. (1) A Mode S transponder shall conform to one of the following five levels —

(a) Level 1 transponder shall have the capabilities determined for —

(i) Mode A identity and Mode C pressure-altitude reporting,

(ii) intermode and Mode S all-call transactions,

(iii) addressed surveillance altitude and identity transaction,

(iv) lockout protocols,

(v) basic data protocols except data link capability reporting, and

(vi) air-air service and squitter transactions;

(b) Level 2 transponders shall have capabilities determined in paragraph (a) and those determined for —

(i) standard length communications (Comm-A and Comm-B),

(ii) data link capability reporting, and

(iii) aircraft identification reporting; or

(c) Level 3 transponders shall have capabilities contained in paragraph (b) and also those determined for ground-to-air extended length message communications;

(d) Level 4 transponders shall have capabilities contained in paragraph (c) and those determined for air-to-ground extended length message communications; or

(e) Level 5 transponders shall have capabilities contained in paragraph (d) and those determined for enhanced Comm-B and extended length message communications

(2) An extended squitter transponder shall have the capabilities in subregulation (1) (b), (c), (d) or (e), and those capabilities determined for extended squitter operation and ACAS cross-link operation.

(3) A transponder with capabilities referred to under subregulation (2) shall be designated with a suffix "e".

(4) A transponder with the ability to process surveillance identifier codes shall have the capabilities in subregulation (1) (a), (b), (c), (d) or (e) and those determined for surveillance identifier code operation.

(5) A transponder with capability referred to under subregulation (4) shall be designated with a suffix "s".

(6) A surveillance identifier code capability shall be provided in accordance with subregulation (4) and (5) for a Mode S transponder installed on or after 1 January 2003, and by all Mode S transponders by 1 January 2005.

(7) An extended squitter non-transponder device that is capable of broadcasting extended squitter that is not part of a Mode S transponder shall conform to all the 1090 MHz RF signals in space requirements specified for a Mode S transponder, except for transmit power levels for the identified equipment class in regulation 73.

(8) A Mode S transponder used by international civil air traffic shall conform to requirements of Level 2 in subregulation 1 (*b*).

(9) A Mode S transponder installed on an 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 provided for in paragraph 1.1.2.10.4 set out in Schedule 1:

Provided the aircraft individual certificate of airworthiness is first issued on or after 1 January 1990, or a Mode S transponder carriage is required based on regional air navigation agreement in accordance with regulation 19 (10) and (11).

22. (1) A capability reporting in a Mode S acquisition squitter unsolicited downlink transmissions shall be provided in accordance with the paragraph 1.1.2.8.5.1 set out in Schedule 1 for all Mode S transponders installed on or after 1 January 1995.

(2) A transponder equipped for extended squitter operation shall, have a means to disable acquisition squitter when extended squitter are being emitted.

23. A transponder manufactured before 1 January 1999 shall be permitted to transmit a burst of 16 Extended Length Message segments at a minimum power level of 20 dBW, in order to facilitate the conversion of existing Mode S transponders, to include a full Mode S capability.

24. A secondary surveillance radar Mode S address shall, be one of 16 777 214 twenty-four bit aircraft addresses allocated by International Civil Aviation Organisation to the state of registry or common mark registering authority and assigned in accordance with paragraph 1.1.2.4.1.2.3.1.1. set out in Schedule 1.

25. (1) The manufacture shall ensure that —
   (*a*) human factors principles shall be observed in the design and certification of surveillance radar and collision avoidance system;
   (*b*) transponder controls which is not intended to be operated in flight shall not be directly accessible to the flight crew;
   (*c*) the operation of transponder controls, intended for use during flight shall be evaluated to ensure they are logical and tolerant to human error;
   (*d*) unintentional transponder mode switching is minimized where transponder functions are integrated with other system controls; and
   (*e*) the flight crew shall always have access to the information of the operational state of the transponder.

PART IV — *Airborne Collision Avoidance System*

26. An Airborne Collision Avoidance System I shall perform the following functions —
   (*a*) surveillance of nearby secondary surveillance radar transponder-equipped aircraft; and

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

27. The radio frequency characteristics of all Airborne Collision Avoidance System I signal shall conform to provisions of paragraphs 1.1.1.1 to 1.1.1.6, and 1.1.2.1 and 1.1.2.4. set out in Schedule 1.

28. (1) The effective radiated power of an Airborne Collision Avoidance System I transmission at 0-degree elevation relative to the longitudinal axis of the aircraft shall not exceed 24 dBW.

(2) When Airborne Collision Avoidance System I is not transmitting an interrogation, the effective radiated power in any direction shall not exceed 70 dBm.

(3) An Airborne Collision Avoidance System I interrogator shall control its interrogation rate and power or both in all secondary surveillance radar modes to minimize interference effects.

(4) An Airborne Collision Avoidance System I shall monitor the rate that own transponder replies to interrogations to ensure that subregulation (7) is complied with.

(5) An Airborne Collision Avoidance System I shall count the number of Airborne Collision Avoidance System II and Airborne Collision Avoidance System III interrogators in the vicinity to ensure that subregulations (7) or (8) are complied with.

(6) An Airborne Collision Avoidance System I count in subregulation (5) shall be —

(a) obtained by monitoring Airborne Collision Avoidance System broadcasts (UF = 16); and

(b) updated as the number of distinct Airborne Collision Avoidance System aircraft addresses received within the previous 20 seconds period at a minimum frequency of at least 1 Hz.

(7) The interrogator power shall not exceed the limits defined in paragraph 1 set out in Schedule 2.

(8) An Airborne Collision Avoidance System I that uses Mode S interrogations shall not cause greater interference effects than an Airborne Collision Avoidance System I using Mode A/C interrogations only.

29. (1) An Airborne Collision Avoidance System shall perform the following functions —

(a) surveillance;

(b) generation of Traffic Advisories;

(c) threat detection;

(d) generation of Resolution Advisories;

(e) coordination; and

(f) communication with ground stations.

(2) An Airborne Collision Avoidance System equipment shall perform functions in subregulation (1) (b), (c), (d), and (e) on each cycle of operation and the duration of the cycle shall not exceed 1.2 seconds.

30. (1) An Airborne Collision Avoidance System shall —

(a) interrogate SSR Mode A/C and Mode S transponders in other aircraft and detect the transponder replies;

(b) measure the range and relative bearing of responding aircraft and using these measurements and information conveyed by transponder replies;

(c) estimate the relative positions of each responding aircraft; and

(*d*) include provisions for achieving such position determination in the presence of ground reflections, interference and variations in signal strength.

(2) An Airborne Collision Avoidance System shall generate an established track, with at least a 0.90 probability that the track is established 30 seconds before closest approach, on aircraft equipped with transponders, when all the following conditions are satisfied —

(*a*) the elevation angles of these aircraft are within ±10 degrees relative to the Airborne Collision Avoidance System aircraft pitch plane;

(*b*) the magnitudes of these aircraft's rates of change of altitude are less than or equal to 51 m/s (10 000 ft/min);

(*c*) the transponders and antennas of these aircraft meet the standards of Part IV of these Regulations;

(*d*) the closing speeds and directions of these aircraft, the local density of SSR transponder-equipped aircraft and the number of other Airborne Collision Avoidance System interrogators in the vicinity, as determined by monitoring airborne collision avoidance system broadcasts, satisfy the conditions specified in Table 1-1 set out in Schedule 2; and

(*e*) the minimum slant range is equal to or greater than 300 m (1 000 ft).

(3) An Airborne Collision Avoidance System shall continue to provide surveillance with no abrupt degradation in track establishment probability, as any one of the condition bounds defined in Schedule 1.1.1 is exceeded.

(4) An Airborne Collision Avoidance System shall not track Mode S aircraft that report that it is on the ground.

(5) An Airborne Collision Avoidance System shall achieve the required tracking performance when —

(*a*) the average SSR Mode A/C asynchronous reply rate from a transponder in the vicinity of the Airborne Collision Avoidance System aircraft is 240 replies per second; and

(*b*) the peak interrogation rate received by an individual transponder under surveillance is 500 per second.

(6) 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 10-2, and for an established Mode S track this probability shall be less than 10-6:

Provided that these limits are not exceeded in any traffic environment.

(7) The range shall be measured with a resolution of 14.5 m (1/128 NM) or better.

(8) The errors in the relative bearings of the estimated positions of intruders shall not exceed 10 degrees rms.

(9) The effective radiated power of an Airborne Collision Avoidance System transmission at 0-degree elevation relative to the longitudinal axis of the aircraft shall not exceed 27 dBW.

(10) When Airborne Collision Avoidance System is not transmitting an interrogation, the effective radiated power in any direction shall not exceed −70 dBm.

(11) An Airborne Collision Avoidance System interrogator operating below a pressure-altitude of 5 490 m (18 000 ft) shall control its interrogation rate or power to conform with the following specific inequalities —

(*a*) Airborne Collision Avoidance System shall count the number of other Airborne Collision Avoidance System II and III interrogators in the vicinity to ensure that the interference limits are met, and this count shall be obtained by monitoring Airborne Collision Avoidance System broadcasts (UF = 16), and each Airborne Collision Avoidance System shall monitor such broadcast interrogations to determine the number of other Airborne Collision Avoidance System within detection range; and

(*b*) Airborne Collision Avoidance System shall adjust its interrogation rate and interrogation power such that the following inequalities remain true, except as provided in Schedule 2 —

(i) all air-to-air coordination 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 Schedule 2 for the duration of the RA,

(ii) when the Airborne Collision Avoidance System aircraft indicates that it is on the ground, Airborne Collision Avoidance System interrogations shall be limited by setting the number of other Airborne Collision Avoidance System II and III aircraft (*na*) count in the interference limiting inequalities to a value that is three times the value obtained based on Airborne Collision Avoidance System broadcasts received with a transponder receiver threshold of −74 dBm, and when a Mode A/C interrogation power is reduced because of interference limiting, the Mode A/C interrogation power in the forward beam shall be reduced first until the forward sequence matches the right and left sequences, and the forward, right and left interrogation powers shall then sequentially be reduced until they match the rear interrogation power, and further reduction of Mode A/C power shall be accomplished by sequentially reducing the forward, side and rear interrogation powers, and

(iii) when transmissions from Airborne Collision Avoidance System units above 5 490 m (18 000 ft) altitude, and each Airborne Collision Avoidance System interrogator operating above a pressure-altitude of 5 490 m (18 000 ft) shall control its interrogation rate or power or both such that inequalities (1) and (3) in Schedule 2 remain true when n and α are equal to 1, except as provided in subregulation 10 (*b*) (i).

Traffic advisories

31. (1) An Airborne Collision Avoidance System shall provide Traffic advisories to alert the flight crew to potential threats.

(2) The Traffic advisories in subregulation (1) shall be accompanied by an indication of the approximate relative position of potential threats to facilitate visual acquisition.

(3) When a potential threat is shown on a traffic display, it shall be displayed in amber or yellow.

(4) When any Resolution Advisory or Traffic Advisory is displayed, proximate traffic within 11 km (6 NM) range and, if altitude reporting, ±370 m (1 200 ft) altitude shall be displayed.

(5) The proximate traffic in subregulation (4) shall be distinguished by color or symbol type from threats and potential threats, which shall be more prominently displayed.

(6) When any Resolution Advisory or Traffic Advisory is displayed, visual acquisition of the threat or potential threat shall not be adversely affected by the display of proximate traffic or other data unrelated to collision avoidance.

(7) The criteria for a Traffic Advisory shall be satisfied before that of a Resolution Advisory.

(8) The minimum Traffic advisory warning time for intruders reporting altitude shall not be 20 seconds greater than the minimum warning time for the generation of the resolution advisory.

32. (1) An Airborne Collision Avoidance System shall evaluate appropriate characteristics of each intruder to determine whether it is a threat. *Threat detection*

(2) The minimum 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) sensitivity level of intruder's Airborne Collision Avoidance System, Si.

(3) For an intruder not equipped with Airborne Collision Avoidance System II or Airborne Collision Avoidance System III, Surveillance Identifier shall be set to 1.

(4) The minimum characteristics of own aircraft that is used to identify a threat shall include —

(a) altitude;
(b) rate of change of altitude; and
(c) sensitivity level of own Airborne Collision Avoidance System.

(5) An Airborne Collision Avoidance System shall be capable of operating at a number of sensitivity levels, and 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
(c) $S = 3$-7, further levels that enable the issue of RAs that provide the warning times indicated in Table 2.2 set out Schedule 2 as well as TAs.

(6) The selection of own Airborne Collision Avoidance System sensitivity level shall be determined by Sensitivity Level Control commands which shall be accepted from following sources —

(a) SLC command generated automatically by Airborne Collision Avoidance System based on altitude band or other external factors;
(b) SLC command from pilot input; and
(c) SLC command from Mode S ground stations.

(7) The acceptable SLC command codes shall include —

	Coding
(a) for SLC based on altitude band	2-7
(b) for SLC from pilot input	0,1,2
(c) for SLC from Mode S ground stations	0,2-6.

(8) Where an Airborne Collision Avoidance System selects an SLC command based on altitude, hysteresis shall be applied to the nominal altitude thresholds which SLC command value changes are required as follows —

(a) for a climbing Airborne Collision Avoidance System aircraft, the SLC command shall be increased at the appropriate altitude threshold plus the hysteresis value; and

(b) for a descending Airborne Collision Avoidance System aircraft, the SLC command shall be decreased at the appropriate altitude threshold minus the hysteresis value.

(9) An SLC command set by the pilot at the value 0 shall, indicate the selection of the "automatic" mode for which the SLC shall be based on the other commands.

(10) For a SLC commands transmitted via a Mode S ground station, the value 0 shall indicate that the station concerned is not issuing a SLC command and that an SLC shall be based on the other commands, including non-0 commands from other Mode S ground station, and the Airborne Collision Avoidance System shall not process an uplinked SLC value of 1.

(11) ATS authorities shall ensure that procedures are in place to inform pilots of any ATS selected SLC command code other than 0.

(12) An Airborne Collision Avoidance System sensitivity level shall be set to the smallest non-0 SLC command received from any of the sources listed in subregulations (5) to (11).

(13) When the sensitivity level of own Airborne Collision Avoidance System is three 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 Airborne Collision Avoidance System, and the sensitivity level of the intruder's Airborne Collision Avoidance System, Si.

(14) The parameter values used for Traffic advisory generation that depend on sensitivity level shall be selected on the same basis as those for RAs (1.4) 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. In this case, 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.

Resolution Advisories (RAs)

33. (1) An Airborne Collision Avoidance System shall generate an RA for all threats except, where —

(a) it is not possible to select an RA that can be predicted to provide adequate separation because of uncertainty in the diagnosis of the intruder's flight path; or

(b) there is a high risk that a maneuver by the threat will negate the RA.

(2) All threats that are shown on a traffic display shall be displayed in red.

(3) Once an RA has been generated against a threat, it shall be maintained or modified until tests that are less stringent than those for threat detection indicate on two consecutive cycles that the RA may be cancelled, at which time it shall be cancelled.

(4) An Airborne Collision Avoidance System shall generate the RA —

(a) that is predicted, to provide adequate separation from all threats;

(b) that has the least effect on the current flight path of the Airborne Collision Avoidance System aircraft; and

(c) consistent with other provisions in these Regulations.

(5) An RA shall not recommend or continue to recommend a maneuver or maneuver restriction that, considering the range of probable threat trajectories, is more likely to reduce separation than increase it.

(6) A new Airborne Collision Avoidance System installations made after 1 January 2014 shall monitor own aircraft's vertical rate to verify compliance with the RA sense.

(7) An Airborne Collision Avoidance System shall —

(*a*) stop assuming compliance where non-compliance is detected and shall assume the observed vertical rate;

(*b*) be compliant with the requirement in paragraph (*a*) and subregulation (6);

(*c*) comply with the requirements set out in subregulation (6) and paragraph (*a*); and

(*d*) generate an RA consistent with the performance capability of the aircraft.

(8) A descend RA shall not be generated or maintained when own aircraft is below 300 m (1 000 ft) above ground level.

(9) An Airborne Collision Avoidance System shall not operate in sensitivity levels 3-7 when own aircraft is below 300 m (1 000 ft) above ground level.

(10) An Airborne Collision Avoidance System shall not reverse the sense of an RA from one cycle to the next, except as permitted in subregulation (11) to ensure coordination or when the predicted separation at closest approach for the existing sense is inadequate.

(11) Where an RA Component received from an equipped threat is incompatible with the current RA sense, an Airborne Collision Avoidance System shall modify the RA sense to conform with the received RAC if own aircraft address is higher in value than that of the threat.

(12) An Airborne Collision Avoidance System shall not modify an RA sense, in a way that makes the RA sense incompatible with an RAC received from an equipped threat if own aircraft address is higher in value than that of the threat.

(13) Subject to the requirement that a descend RA is not generated at low altitude, 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.

(14) An RA shall not be weakened if it is likely that it would subsequently need to be strengthened.

(15) When an RAC is received from a threat before the Airborne Collision Avoidance System generates an RAC for that threat, the RA generated shall be compatible with the RAC:

Provided that such an RA is more likely to reduce separation than increase it and own aircraft address is lower in value than that of the threat.

(16) The RA sense, strength and attributes on each cycles of an RA, shall be encoded in the active RA subfield, and when the active RA subfield has not been refreshed for an interval of 6 seconds, it shall be set to 0, along with the MTE subfield in the same message.

(17) The system delay from receipt of the relevant SSR reply to presentation of an RA sense and strength to the pilot shall be short and shall not exceed 1.5 seconds.

34. (1) An Airborne Collision Avoidance System shall, in a multi-aircraft situation, coordinate with each equipped threat individually.

Coordination and communication

(2) An Airborne Collision Avoidance System shall prevent simultaneous access to stored data by concurrent processes, during resolution message processing.

(3) An Airborne Collision Avoidance System cycle shall transmit a coordination interrogation to each equipped threat, unless generation of an RA is delayed because it is not possible to select an RA that can be predicted to provide adequate separation.

(4) When an RAC has been received from a threat before Airborne Collision Avoidance System selects an RAC for that threat, the selected RAC shall be compatible with the received RAC unless —

(a) no more than three cycles have elapsed since the RAC was received;

(b) the RAC is altitude-crossing; and

(c) own aircraft address is lower in value than that of the threat, in which case Airborne Collision Avoidance System shall select its RA independently.

(5) Where an RAC received from an equipped threat is incompatible with the RAC selected by Airborne Collision Avoidance System for that threat, the Airborne Collision Avoidance System shall modify the selected RAC to be compatible with the received RAC if own aircraft address is higher in value than that of the threat.

(6) An Airborne Collision Avoidance System shall, within the cycle during which an intruder ceases to be a reason for maintaining the RA, send a resolution message to that intruder by means of a coordination interrogation.

(7) A resolution message sent under subregulation (6) shall include the cancellation code for the last RAC sent to that intruder while it was a reason for maintaining the RA.

(8) An Airborne Collision Avoidance System coordination interrogation shall be transmitted until a coordination reply is received from the threat, up to a minimum of six and not more than 12 attempts.

(9) The successive interrogations in subregulation (7) shall be nominally equally spaced over a period of 100 ±5 ms.

(10) An Airborne Collision Avoidance System shall continue its regular processing sequence when the maximum number of attempts are made, and no reply is received.

(11) An Airborne Collision Avoidance System shall provide parity protection for all fields in the coordination interrogation that convey RAC information.

(12) When an Airborne Collision Avoidance System reverses its sense against an equipped threat, the resolution message that is sent on the current and subsequent cycles to that threat shall contain both the newly selected RAC and the cancellation code for the RAC sent before the reversal.

(13) When a vertical RA is selected, the vertical RAC (VRC) that the own Airborne Collision Avoidance System includes in a resolution message to the threat shall be as follows —

(a) "do not pass above" when the RA is intended to provide separation above the threat; and

(b) "do not pass below" when the RA is intended to provide separation below the threat.

(14) Resolution messages shall be processed in the order in which they are received, and with delay limited to that required to prevent possible concurrent access to stored data and delays due to the processing of previously received resolution messages.

(15) Resolution messages that are being delayed shall be temporarily queued to prevent possible loss of messages.

(16) The processing of a resolution message shall include decoding the message and updating the appropriate data structures with the information extracted from the message.

(17) An RAC or an RAC cancellation received from another Airborne Collision Avoidance System shall be rejected if the encoded sense bits indicate the existence of a parity error or if undefined value is detected in the resolution message.

(18) An RAC or an RAC cancellation received without parity errors and without undefined resolution message values shall be considered valid.

(19) A valid RAC received from another Airborne Collision Avoidance System shall be stored or he used to update the previously stored RAC corresponding to that Airborne Collision Avoidance System.

(20) A valid RAC cancellation shall cause the previously stored RAC to be deleted.

(21) A stored RAC that has not been updated for an interval of six seconds shall be deleted.

(22) A valid RAC or RAC cancellation received from another Airborne Collision Avoidance System shall be used to update the RAC record.

(23) When a bit in a RAC record has not been refreshed for an interval of six seconds by any threat, that bit shall be set to zero.

(24) When an Airborne Collision Avoidance System RA exists, the Airborne Collision Avoidance System shall —

(*a*) transfer to its Mode S transponder an RA report for transmission to the ground in a Comm-B reply; and

(*b*) transmit periodic RA broadcasts.

(25) An Airborne Collision Avoidance System shall store SLC commands from Mode S ground stations.

(26) An SLC command received from a Mode S ground station shall, remain effective until replaced by an SLC command from the same ground station as indicated by the site number contained in the IIS subfield of the interrogation.

(27) When an existing stored SLC command from a Mode S ground station is not refreshed within four minutes, or when the SLC command received has the value 15, the stored SLC command for that Mode S ground station shall be set to 0.

35. (1) Where an Airborne Collision Avoidance System RA exists, the Airborne Collision Avoidance System shall — Provisions for ACAS communication with ground stations

(*a*) transfer to its Mode S transponder an RA report for transmission to the ground in a Comm-B reply; and

(*b*) transmit periodic RA broadcasts.

(2) An Airborne Collision Avoidance System shall store SLC commands from Mode S ground stations.

(3) An SLC command received from a Mode S ground station shall remain effective until replaced by an SLC command from the same ground station as indicated by the site number contained in the IIS subfield of the interrogation.

(4) Where an existing stored command from a Mode S ground station is not refreshed within four minutes, or if the SLC command received has the value 15 the stored SLC command for that Mode S ground station shall be set to zero.

36. (1) An Airborne Collision Avoidance System shall transfer data to its Mode S, and shall transfer — Provisions for data transfer between ACAS and its mode S transponder

(*a*) RA information to its Mode S transponder for transmission in an RA report and in a coordination reply;

(*b*) current sensitivity level to its Mode S transponder for transmission in a sensitivity level report; and

(*c*) capability information to its Mode S transponder for transmission in a data link capability report.

(2) A Mode S transponder shall transfer data to its Airborne Collision Avoidance System, and the Airborne Collision Avoidance System shall receive from its Mode S transponder —

(*a*) sensitivity level control commands transmitted by Mode S ground stations;

(*b*) Airborne Collision Avoidance System broadcast messages transmitted by other Airborne Collision Avoidance System; and

(*c*) resolution messages transmitted by other Airborne Collision Avoidance System for air-air coordination purposes.

ACAS protocols **37.** (1) An Airborne Collision Avoidance System shall use the Mode C-only all-call interrogation for surveillance of aircraft equipped with Mode A/C transponders.

(2) A surveillance interrogation shall use a sequence of interrogations with increasing power surveillance being preceded by an S1-pulse to reduce interference and improve Mode A/C target detection.

(3) An Airborne Collision Avoidance System shall monitor 1 090 MHz for Mode S acquisition squitters (DF = 11).

(4) An Airborne Collision Avoidance System shall detect the presence and determine the address of Mode S-equipped aircraft using their Mode S acquisition squitters (DF = 11) or extended squitter (DF = 17).

(5) On first receipt of a 24-bit aircraft address from an aircraft that is determined to be within the reliable surveillance range of ACAS based on reception, reliability and that is within an altitude band 3 050 m (10 000 ft) above and below own aircraft, an Airborne Collision Avoidance System shall transmit a short air-air interrogation (UF = 0) for range acquisition.

(6) A surveillance interrogation shall be —

(*a*) transmitted at least once every five cycles when the altitude condition in subregulation (5) is satisfied;

(*b*) transmitted with each cycle, if the range of the detected aircraft is less than 5.6 km (3 NM) or the calculated time to closest approach is less than 60 seconds:

Provided both the detected and own aircraft proceed from their current positions with unaccelerated motion and that the range at closest approach equals 5.6 km (3 NM); and

(*c*) suspended for a period of five cycles if —

(i) a reply was successfully received,

(ii) own aircraft and intruder aircraft are operating below a pressure-altitude of 5 490 m (18 000 ft), and

(iii) the range of the detected aircraft is greater than 5.6 km (3 NM) and the calculated time to closest approach exceeds 60 seconds:

Provided that both the detected and own aircraft proceed from their current positions with unaccelerated motion and that the range at closest approach equals 5.6 km (3 NM).

(7) An Airborne Collision Avoidance System shall use the short air-air surveillance format (UF = 0) for range acquisition and set AQ = 1 and RL = 0 in an acquisition interrogation.

(8) An Airborne Collision Avoidance System shall use the short air-air surveillance format (UF = 0) with RL = 0 and AQ = 0 for tracking interrogations.

(9) A surveillance replies protocol shall be as described in subregulation 47 (1).

(10) An Airborne Collision Avoidance System broadcast shall be made nominally every eight to 10 seconds at full power from the top antenna.

(11) An installation using directional antennas shall operate in such manner that a complete circular coverage is provided nominally every eight to 10 seconds.

(12) An Airborne Collision Avoidance System shall, transmit UF = 16 interrogations, with AQ = 0 and RL = 1 when another aircraft reporting RI = 3 or 4 is declared a threat.

(13) The MU field shall contain the resolution message in the subfields specified paragraph 7.2 set out in Schedule 2.

(14) A coordination reply protocol shall be as described in regulation 47 (2).

(15) An RA report to Mode S ground station protocol shall be as described in regulation 48 (1) and (2).

(16) The RA broadcasts shall, be transmitted at full power from the bottom antenna at jittered, nominally eight seconds intervals for the period that the RA is indicated.

(17) The RA broadcast shall include the MU field as specified in paragraph 7.2.4 set out in Schedule 2.

(18) The RA broadcast shall describe the most recent RA that existed during the preceding eight seconds period.

(19) Installations using directional antennas shall operate such that a complete circular coverage is provided nominally every eight seconds and the same RA sense and strength is broadcast in each direction.

(20) The data link capability report protocols shall be as described in regulation 48 (3).

(21) An Airborne Collision Avoidance System shall act upon an SLC command, when TMS has the value 0 and DI is either one or seven in the same interrogation.

38. (1) The RF characteristics of all Airborne Collision Avoidance System signals shall conform to the standards in paragraphs 1.1.1.1 to 1.1.1.6;, 1.1.2.1, 1.1.2.3, 1.1.2.5 and 1.1.2.8 set out in Schedule 1. — *Signal formats*

(2) The data encoding of all Airborne Collision Avoidance System signals shall conform to the standards in paragraph 1.1.2.3 set out in Schedule 1.

39. (1) The air-air surveillance and communication formats which are used by Airborne Collision Avoidance System shall, conform to those as set out in Figure 2-1 of the Schedule 2. — *Field description*

(3) The significance of the coding of the downlink request, air-air reply information fields shall be as contained in paragraph 5 set out in Schedule 2.

40. An Airborne Collision Avoidance System fields and sub-fields shall be defined in paragraph 6 set out in Schedule 2. — *ACAS fields and subfields*

41. (1) An Airborne Collision Avoidance System shall be provided with interfaces, the following input data shall be provided to as the minimum — *ACAS equipment characteristics*

    (*a*) aircraft address code;

    (*b*) air-air and ground-air Mode S transmissions received by the Mode S transponder for use by Airborne Collision Avoidance System;

    (*c*) own aircraft's maximum cruising true airspeed capability;

    (*d*) pressure-altitude; and

    (*e*) radio altitude.

(2) An Airborne Collision Avoidance System shall transmit interrogations and receive replies via two antennas, one mounted on the top of the aircraft and the other on the bottom of the aircraft.

(3) The top-mounted antenna shall be directional and capable of being used for direction finding.

(4) An Airborne Collision Avoidance System polarisation transmission shall be nominally vertical.

(5) The radiation pattern in elevation of an antenna when installed on an aircraft shall, be nominally equivalent to that of a quarter-wave monopole on a ground plane.

42. (1) An Airborne Collision Avoidance System shall be capable of receiving squitters through the top and bottom antennas.

(2) An Airborne Collision Avoidance System interrogation shall not be transmitted simultaneously on both antennas.

(3) The altitude data for an aircraft provided to Airborne Collision Avoidance System shall be obtained from the source that provides the basis for own Mode C or Mode S reports and they shall be provided at the finest quantisation available.

(4) A source providing a resolution finer than 7.62 m (25 ft) shall be used.

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

(6) Two altitude data sources shall be used and compared in order to detect errors before provision to an Airborne Collision Avoidance System.

(7) When the comparison of two altitude data sources indicates that one of the sources is in error, the provisions of regulation 43 (3) shall apply.

43. (1) An Airborne Collision Avoidance System shall, continuously perform a monitoring function in order to provide a warning, when any of the following conditions are satisfied —

(*a*) there is no interrogation power limiting due to interference control and the maximum radiated power is reduced to less than that necessary to satisfy the surveillance requirements; or

(*b*) any other failure in the equipment is detected which results in a reduced capability of providing TAs or RAs; or

(*c*) data from external sources indispensable for an Airborne Collision Avoidance System operation are not provided, or the data provided are not credible

(2) An Airborne Collision Avoidance System monitoring function shall, not adversely affect other Airborne Collision Avoidance System functions.

(3) When the Airborne Collision Avoidance System monitoring function detects a failure, Airborne Collision Avoidance System shall —

(*a*) indicate to the flight crew that an abnormal condition exists;

(*b*) prevent any further Airborne Collision Avoidance System interrogations; and

(*c*) cause any Mode S transmission containing own aircraft's resolution capability to indicate that Airborne Collision Avoidance System is not operating.

44. (1) The Mode S transponder shall meet the nominal capabilities as defined paragraph 1.1 set out in Schedule 1.

(2) The Mode S transponder used in conjunction with an Airborne Collision Avoidance System shall have the following capabilities —

(*a*) ability to handle the following formats

Format No.	Format name
UF = 16	Long air-air surveillance interrogation
DF = 16	Long air-air surveillance reply;

(*b*) ability to receive long Mode S interrogations (UF = 16) and generate long Mode S replies (DF = 16) at a continuous rate of 16.6 ms (60 per second);

(*c*) means for delivering the Airborne Collision Avoidance System data content of all accepted interrogations addressed to the Airborne Collision Avoidance System equipment;

(*d*) antenna diversity;

(*e*) mutual suppression capability; and

(*f*) inactive state transponder output power restriction.

(3) When a Mode S transponder transmitter is in the inactive state, the peak pulse power at 1 090 MHz ±3 MHz at the terminals of the Mode S transponder antenna shall not exceed −70 dBm.

45. (1) A Mode S transponder shall receive from its Airborne Collision Avoidance System —

<div align="right">Data transfer from ACAS to its Mode S transponder</div>

(*a*) RA information for transmission in an RA report and in a coordination reply;

(*b*) a current sensitivity level for transmission in a sensitivity level report;

(*c*) capability information for transmission in a data link capability report and for transmission in the RI field of air-air downlink formats DF = 0 and DF = 16; or

(*d*) an indication that RAs are enabled or inhibited for transmission in the RI field of downlink formats zero and 16.

46. The Mode S transponder shall transfer to its Airborne Collision Avoidance System —

<div align="right">Data transfer from Mode S transponder to its ACAS</div>

(*a*) received sensitivity level control commands transmitted by Mode S stations;

(*b*) received Airborne Collision Avoidance System broadcast messages transmitted by other Airborne Collision Avoidance Systems;

(*c*) received resolution messages transmitted by other Airborne Collision Avoidance Systems for air-air coordination purposes; or

(*d*) own aircraft's Mode A identity data for transmission in an RA broadcast.

47. (1) The Airborne Collision Avoidance System Mode S transponder shall use the short (DF = 0) or long (DF = 16) surveillance formats to reply to Airborne Collision Avoidance System surveillance interrogations.

<div align="right">Communication of ACAS information to other ACAS</div>

(2) The surveillance reply in subregulation (1) shall include —

(*a*) VS field as specified in paragraph 1.1.2.8.2 set out in Schedule 1;

(*b*) RI field as specified paragraph 1.1.2.8.2 set out in Schedule 1, and paragraph 5.1.2 set out in Schedule 2; and

(*c*) SL field as specified in paragraph 8.2.5 set out in Schedule 2.

(3) An Airborne Collision Avoidance System Mode S transponder shall transmit a coordination reply upon receipt of a coordination interrogation from an equipped threat subject to the conditions of subregulation (3).

(4) The coordination reply in subregulation (2) shall use the —

(*a*) long air-air surveillance reply format, DF = 16;

(*b*) VS field as specified in paragraph 1.1.2.8.2 set out in Schedule 1;

(c) RI field as specified in paragraph 1.1.2.8.2 set out in Schedule 1, and as specified paragraph 5.1.2 set out in Schedule 2;

(d) SL field as specified in paragraph 8.2.5 set out in Schedule 2; and

(e) MV field as specified in as specified in paragraph 8.2.5.4 set out in Schedule 2.

(5) Coordination replies shall be transmitted even when the minimum reply rate limits of the transponder are exceeded.

(6) An Airborne Collision Avoidance System Mode S transponder shall reply with a coordination reply to a coordination interrogation received from another Airborne Collision Avoidance System:

Provided the transponder can deliver the Airborne Collision Avoidance System data content of the interrogation to its associated Airborne Collision Avoidance System.

Communication of ACAS information to ground stations

48. (1) An Airborne Collision Avoidance System Mode S transponder shall, during an RA and for 18 ± 1 seconds following the end of the RA, indicate that it has an RA report by setting the appropriate DR field code in replies to a Mode S sensor as specified in paragraph 5.1.1. set out in Schedule 2.

(2) The RA report in subregulation (1) shall —

(a) include the MB fields specified in paragraph 6.2.1 set out in Schedule 2; and

(b) describe the most recent RA that existed during the preceding 18 ± 1 s period.

(3) A Mode S transponder shall indicate the presence of its Airborne Collision Avoidance System to a ground station in the Mode S data link capability report.

Indications to flight crew

49. (1) An indication to the flight crew shall distinguish between preventive and corrective RAs.

(2) When Airborne Collision Avoidance System generates an altitude crossing RA, a specific indication shall be given to the flight crew that it is crossing.

Performance of ACAS II collision avoidance logic

50. The performance requirements of the Airborne Collision Avoidance System II collision avoidance logic shall be as specified in paragraph 7 set out in Schedule 2.

Conditions under which requirements apply

51. (1) The following assumed conditions shall apply to the performance requirements specified in regulations 62 and 63 —

(a) range and bearing measurements and an altitude report are available for the intruder each cycle provided it is within 14 NM, but not when the range exceeds 14 NM;

(b) the errors in the range and bearing measurements conform to standard range and bearing error models;

(c) the intruder's altitude reports, which are its Mode C replies, are expressed in 100 ft quanta;

(d) an altitude measurement that has not been quantized and is expressed with a precision of 1 ft or better is available for own aircraft;

(e) errors in the altitude measurements for both aircraft are constant throughout any particular encounter;

(f) the errors in the altitude measurements for both aircraft conform to a standard altimetry error model;

(g) the pilot responses to RAs conform to a standard pilot model;

(h) the aircraft operate in an airspace in which close encounters, including those in which Airborne Collision Avoidance System generates an RA, conform to a standard encounter model; and

(*i*) Airborne Collision Avoidance System-equipped aircraft are not limited in their ability to perform the maneuvers required by their RAs.

(2) The collision avoidance logic performance shall —

(*a*) not degrade abruptly as the statistical distribution of the altitude errors or the statistical distributions of the various parameters that characterise the standard encounter model or the response of pilot to the advisories are varied; and

(*b*) when surveillance reports are not available on every cycle or when the quantisation of the altitude measurements for the intruder is varied or the altitude measurements for own aircraft are quantized.

52. The simulated range measurements errors shall, be taken from a normal distribution with mean 0 ft and standard deviation 50 ft. *Standard Range Error Model*

53. The simulated bearing measurement errors shall, be taken from a normal distribution with mean 0.0 degrees and standard deviation 10.0 degrees. *Standard Bearing Error Model*

54. A standard altimetry error model shall be defined in paragraph 7 as set out Schedule 2. *Standard altimetry error model*

55. A standard pilot model used in the assessment of the performance of a collision avoidance logic shall be that — *Standard pilot model*

(*a*) any RA is complied with by accelerating to the required rate, if necessary, after an appropriate delay;

(*b*) when the aircraft's current rate is the same as its original rate and the original rate complies with the RA, the aircraft continues at its original rate, which is not necessarily constant due to the possibility of acceleration in the original trajectory;

(*c*) when the aircraft is complying with the RA, its current rate is the same as the original rate and when the original rate changes and consequently becomes inconsistent with the RA, the aircraft continues to comply with the RA;

(*d*) when an initial RA requires a change in altitude rate, the aircraft responds with an acceleration of 0.25 g after a delay of five seconds from the display of the RA;

(*e*) when an RA is modified and the original rate complies with the modified RA, the aircraft returns to its original rate, if necessary, with the acceleration specified in paragraph (*g*) after the delay specified in paragraph (*h*);

(*f*) when an RA is modified and the original rate does not comply with the modified RA, the aircraft responds to comply with the RA with the acceleration specified in paragraph (*g*) after the delay specified in paragraph (*h*);

(*g*) the acceleration used when an RA is modified is 0.25 g unless the modified RA is a reversed sense RA or an increased rate RA in which case the acceleration is 0.35 g;

(*h*) the delay used when an RA is modified is 2.5 seconds unless this results in the acceleration starting earlier than five seconds from the initial RA in which case the acceleration starts five seconds from the initial RA; and

(*i*) when an RA is cancelled, the aircraft returns to its original rate (if necessary) with an acceleration of 0.25 g after a delay of 2.5 seconds.

56. (1) In order to calculate the effect of an Airborne Collision Avoidance System on the risk of collision and the compatibility of an Airborne Collision Avoidance System with Air Traffic Management, set of encounters shall be reated for each of the following —

(*a*) the two aircraft address orderings;

(*b*) the six altitude layers;

(*c*) 19 encounter classes; and

(*d*) nine or 10 VMD bins as specified in paragraph 9.4.3 set out in Schedule 2.

(2) The sets results in subregulation (1) shall be combined using the relative weightings given in regulation 57.

(3) Each set of encounters shall contain at least 500 independent, randomly generated encounters.

(4) The two aircraft trajectories in an encounter shall be constructed with the following randomly selected characteristics —

(*a*) in the vertical plane —

   (i) a vmd from within the appropriate vmd bin,

   (ii) a vertical rate for each aircraft at the beginning of the encounter window, $\dot{z}1$, and at the end of the encounter window, $\dot{z}2$,

   (iii) a vertical acceleration,

   (iv) a start time for the vertical acceleration, and

(*b*) in the horizontal plane —

   (i) an hmd,

   (ii) an approach angle,

   (iii) a speed for each aircraft at closest approach,

   (iv) a decision for each aircraft whether or not it turns,

   (v) the turn extent; the bank angle; and the turn end time,

   (vi) a decision for each aircraft whether its speed changes, and

   (vii) the magnitude of the speed change.

(5) Two models shall be used for statistical distribution of hmd, and for calculations for the effect of an Airborne Collision Avoidance System on the risk of collision, hmd shall be constrained to be less than 500 ft, and for compatibility of an Airborne Collision Avoidance System with ATM, HMD shall be selected from a larger range of values.

57. Encounter classes and weights shall be as contained in paragraph 9.3 set out in Schedule 2.

58. The characteristics of the aircraft trajectories in the vertical plane shall be in accordance with paragraph 9.4 set out in Schedule 2.

59. The characteristics of the aircraft trajectories in the horizontal plane shall be in accordance with paragraph 9.5 set out in Schedule 2.

60. The performance requirements set out in regulations 62 and 63 shall, each apply to three distinct situations in which the following conditions concerning an intruder's Airborne Collision Avoidance System and trajectory shall apply —

(*a*) where an intruder Airborne Collision Avoidance System involved in each encounter is not equipped, it follows a trajectory identical to that which it follows when own aircraft is not equipped; or

(b) where an intruder is Airborne Collision Avoidance System-equipped but follows a trajectory identical to that in the unequipped encounter —
  (i) it follows the identical trajectory regardless of whether or not there is an RA,
  (ii) the intruder Airborne Collision Avoidance System generates an RA and transmits an RAC that is received immediately after any RA is first announced to the pilot of own aircraft,
  (iii) the sense of the RAC generated by the intruder Airborne Collision Avoidance System and transmitted to own aircraft is opposite to the sense of the first RAC selected and transmitted to the intruder by own aircraft,
  (iv) the RAC transmitted by the intruder is received by own aircraft, and
  (v) the requirements apply both when own aircraft has the lower aircraft address and when the intruder aircraft has the lower aircraft address, or
(c) where an intruder is equipped with an Airborne Collision Avoidance System having a collision avoidance logic identical to that of own Airborne Collision Avoidance System —
  (i) the conditions relating to the performance of own aircraft, Airborne Collision Avoidance System and pilot apply equally to the intruder aircraft, Airborne Collision Avoidance System and pilot,
  (ii) RACs transmitted by one aircraft are received by the other, and
  (iii) the requirements apply both when own aircraft has the lower aircraft address and when the intruder aircraft has the lower aircraft address.

61. The Authority shall, when considering alternative collision avoidance logic designs verify that —
(a) the performances of the alternative design are acceptable in encounters involving Airborne Collision Avoidance System units that use existing designs; and
(b) the performances of the existing designs are not degraded using the alternative design.

62. Subject to regulation 51, a collision avoidance logic shall be that, the expected number of collisions is reduced to the number expected in the absence of an Airborne Collision Avoidance System —
(a) when the intruder is not equipped with Airborne Collision Avoidance System, 0.18;
(b) when the intruder is equipped with Airborne Collision Avoidance System but does not respond, 0.32; and
(c) when the intruder is equipped with Airborne Collision Avoidance System and responds, 0.04.

63. (1) The collision avoidance logic shall, be that the proportion of RAs which are a nuisance shall not exceed —
(a) .06 when own aircraft's vertical rate at the time the RA is first issued is less than 400 ft/min; or
(b) .08 when own aircraft's vertical rate at the time the RA is first issued exceeds 400 ft/min.

(2) For purposes of subregulation (1), an RA shall, be considered a nuisance, unless during an encounter in the absence of Airborne Collision Avoidance System, the horizontal separation and the vertical separation are simultaneously less than the values specified in accordance with paragraph 10.1 set out in Schedule 2.

64. Subject to regulation 50, the collision avoidance logic shall be that the proportion of encounters in which, following the RA results in an altitude separation at closest approach with the opposite sign to that occurring in the absence of Airborne Collision Avoidance System not exceed the following values —

(a) when an intruder is not Airborne Collision Avoidance System equipped 0.08;

(b) when an intruder is Airborne Collision Avoidance System and is equipped but does not respond 0.08; or

(c) when an intruder is Airborne Collision Avoidance System equipped and responds 0.12.

65. Subject to regulation 42, the collision avoidance logic shall be the number of RAs resulting in deviations greater than the values indicated and shall not exceed the proportions of the total number of RAs as contained in accordance with paragraph 10.2 set out in Schedule 2.

66. The collision avoidance logic shall, be to reduce as much as practicable the risk of collision and limit the disruption to ATM.

67. (1) An Airborne Collision Avoidance System equipped to receive extended squitter airborne position messages, for passive surveillance of non-threatening intruders shall, utilise the passive information as set out in regulations 68, 69, 70, and 72 (2) to (4).

(2) An Airborne Collision Avoidance System using extended hybrid surveillance mode shall establish a track so that no interrogations are performed when the following conditions are met —

(a) own aircraft position data meets the following minimum level of quality —

   (i) own aircraft horizontal position uncertainty (95 per cent) is < 0.1 NM, and

   (ii) own aircraft horizontal position integrity shall be such that the probability of an undetected position error, which is greater than 0.6 NM radius, is less than 1×10^{-7},

(b) the received signal strength is equal or less than -68 dBm +/-2 dB (extended hybrid surveillance minimum triggering level), or own aircraft is operating on the surface;

(c) the intruder data quality meets the following minimum requirements —

   (i) the ADS-B version number ≥ 2,

   (ii) the reported NIC ≥ 6 (< 0.6 NM),

   (iii) the reported NACp ≥ 7 (< 0.1 NM),

   (iv) the reported SIL = 3,

   (v) the reported SDA = 2 or 3, and

   (vi) the barometric altitude is valid, and

(d) the system shall not use ADS-rebroadcast (ADS-R) and TIS-B data to passively acquire an aircraft.

(3) A track maintained under extended hybrid surveillance mode shall transition to a track maintained under active surveillance mode, if the range and altitude of hybrid threat criteria are satisfied.

(4) A track under extended hybrid surveillance mode shall transition to a track under hybrid surveillance mode if —

(a) the signal indicates a high probability to be in proximity, that is, signal > Extended Hybrid Surveillance MTL, except when operating on the airport surface; or

(*a*) intruder data or own data quality does not meet minimum requirements.

68. (1) An Airborne Collision Avoidance System shall validate the position of an intruder reported by extended squitter, by determining the relative range and relative bearing as computed from the position and geographical heading of own aircraft and the intruder's position as reported in the extended squitter.

(2) Subject to subregulation (1), the range, relative bearing and the altitude reported in the squitter shall, be compared to the range, relative bearing and altitude determine by active Airborne Collision Avoidance System interrogations.

(3) The extended squitter data validity shall be determined by the difference between the derived, measured range, and relative bearing, and the squitter and reply altitude shall be computed and used as threat provided in regulation 55.

(4) When any of the validation tests provided under subregulation (3) fail, active surveillance shall be used to track the intruder.

69. (1) An intruder's track shall be updated at least as frequently as required in the absence of an extended squitter data.

(2) When a track is updated using squitter information the time at which an active interrogation would be next required shall be calculated.

(3) An active interrogation shall be made at that time, if a further squitter has not been received before the interrogation is due.

70. (1) An intruder shall be tracked under active surveillance if it is a near threat, as determined by separate tests done once per second on the range and altitude of the aircraft.

(2) The tests in subregulation (1) shall consider an intruder as a near threat before it becomes a potential threat, and trigger a traffic advisory as provided under regulation 51.

71. (1) When an aircraft is being tracked using passive surveillance, periodic active interrogations shall be performed to validate and monitor the extended squitter data as set out in regulation 53 and shall be performed for each interrogation.

(2) The rates of revalidation shall be once per minute for a non-threat and once per 10 seconds for a near threat.

72. (1) When the following condition are met for a track being updated via passive surveillance data the aircraft shall be declared an active track and shall be updated on the active range measurements once per second for as long as the list (*a*) to (*c*) below condition are met —

a) $|a| \leqslant 10\,000$ ft and both;

b) $|a| \leqslant 3\,000$ ft or $|a - 3\,000$ ft$| / |\dot{a}| \leqslant 60$ s; and

c) $r \leqslant 3$ NM or $(r - 3$ NM$) / |\dot{r}| \leqslant 60$ s;

where: a = intruder altitude separation in ft

$\dot{a}$ = altitude rate estimate in ft/s

r = intruder slant range in NM

$\dot{r}$ = range rate estimate in NM/s

(2) A near threat, potential threat or threat shall be tracked using active surveillance.

(3) A track under active surveillance shall transition to passive surveillance if it is not a near threat, potential threat or a threat.

(4) The tests used to determine whether a track is no longer a near threat shall, be similar to those used in regulation 55 but with larger thresholds in order to have hysteresis which prevents the possibility of frequent transitions between active and passive surveillance.

ACAS operation
with an improved
receiver
Minimum
Triggering
Level (MTL)

73. An Airborne Collision Avoidance System operating with a receiver having a minimum triggering level more sensitive than –74 dBm shall implement the following specified capabilities —

Dual minimum triggering levels:

(a) the Airborne Collision Avoidance System receiver shall, be capable of setting an indication for each squitter reception whether the reply would have been detected by an Airborne Collision Avoidance System operating with a conventional MTL (–74 dBm); or

(b) squitter receptions received at the conventional MTL shall, be passed to the Airborne Collision Avoidance System surveillance function for further processing, and squitter receptions that do not meet this condition shall not be passed to the Airborne Collision Avoidance System surveillance function;

Dual or re-triggerable reply processor the Airborne Collision Avoidance System Mode S reply processing function shall —

(a) use separate reply processors for Mode S reply formats received at or above the conventional MTL and a separate reply processor for Mode S reply formats received below the conventional MTL, or

(b) use a Mode S reply processor that will re-trigger if it detects a Mode S preamble that is 2 to 3 dB stronger than the reply that is currently being processed.

PART V – *Mode S Extended Squitter*

74. (1) An aircraft, surface vehicles and fixed obstacles supporting a (ADS)-B capability shall incorporate the (ADS)-B message generation function and the (ADS)-B message exchange function (transmit) as depicted in Figure 3-1 and 3-2 set out in Schedule 3.

(2) An (ADS)-B transmission from aircraft shall include position, aircraft identification and type, airborne velocity, and event driven messages including emergency or priority information.

(3) An extended squitter transmitting equipment shall use the latest versions available of formats and protocols.

(4) A Mode S extended squitter transmitting equipment shall be classified according to the unit's range capability and the set of parameters, that it can transmit consistent with the following definition of general equipment classes and the specific equipment classes defined in accordance with Tables 3-1 set out in Schedule 3 —

(a) an extended squitter airborne systems support an interactive capability incorporating, both an extended squitter transmission capability, that is, (ADS)-B OUT with a complementary extended squitter reception capability that is, (ADS)-B IN in support of onboard (ADS)-B applications;

(b) class B extended squitter systems provide a transmission only, that is, (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) A class A extended squitter airborne system shall have transmitting and receiving subsystem characteristics of the same class, that is A0, A1, A2, or A3 as provided under subregulation (1) and regulation 63 (2).

75. (1) A protection against reception of corrupted data from the source providing the position shall, be satisfied by error detection on the data inputs and the appropriate maintenance of the installation.

(2) When an independent control of the ADS-B OUT function is provided, the operational state of the ADS-B OUT function shall always be indicated to the flight crew.

76. (1) A ground station supporting a Traffic Information Service-B TIS-B capability shall incorporate the TIS-B message generation function and the TIS-B message exchange function (transmit).

(2) An extended squitter message for TIS-B shall, be transmitted by an extended squitter ground station when connected to an appropriate source of surveillance data.

(3) The maximum transmission rate and effective radiated power of the transmission shall be controlled to avoid unacceptable levels of RF interference to other 1 090 MHz systems under subregulation (2) that is, SSR and Airborne Collision Avoidance System.

77. (1) A surface vehicle supporting any versions of extended squitter ADS-B capability shall, transmit extended squitter messages as set out regulation 67 (2).

(2) The position source and equipment installed in a surface vehicle to transmit extended squitter version two messages shall, support the following performance characteristics —

(a) the Navigation Accuracy Category Position or the navigation position data shall be greater than or equal to nine, or a 95 per cent accuracy bound on horizontal position less than 30 metres;

(b) the Navigation Accuracy Category Velocity for the navigation velocity data shall, be greater than or equal to two, a velocity error less than three meters per second;

(c) the Navigation Accuracy Category Position and National Accuracy Category Velocity minimum values shall, be met at a minimum availability of 95 per cent; and

(d) the system design assurance parameter shall, be equal to one 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}.

78. (1) A Mode S extended squitter receiving systems shall perform the message exchange function receive and the report assembler function.

(2) The required functionality and performance characteristics for the Mode S extended squitter receiving system may vary depending on the ADS-B and TIS-B client applications to be supported and the operational use of the system.

(3) A Airborne Mode S extended squitter receivers shall be consistent with the definition of receiving system classes shown in Table 3-3 set out in Schedule 3.

79. (1) The message exchange function shall, include the 1 090 MHz receiving antenna and the radio, equipment, receiver, demodulator, decoder, data buffer, sub-functions.

(2) An airborne Mode S extended squitter receiving system shall, support the reception and decoding of all extended squitter messages as listed in Table 3-3 of the Schedule 3.

(3) An ground ADS-B extended squitter receiving system shall support the reception and decoding of the extended squitter message types that convey information needed to support the generation of the ADS-B reports of the types required by the client ATM ground applications.

(4) An airborne Mode S extended squitter receiver, demodulation or decoder shall employ the reception techniques and have a receiver minimum trigger threshold level as listed in Table 3-3 set out in Schedule 3, as a function of the airborne receiver class.

(5) A reception technique and MTL for extended squitter ground receiver shall be selected to provide the reception performance, range and update rates, as required by the client Air Traffic Management ground applications.

(6) A Class A1, A2 and A3 airborne receiving systems shall, include the following features to provide improved probability of a Mode S extended squitter reception, in the presence of multiple overlapping Mode A/C fruit 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;

(b) enhanced error detection and correction; and

(c) enhanced bit and confidence declaration techniques applied to the airborne receiver classes as shown below —

    (i) Class A1 – Performance equivalent to or better than the use of the Centre Amplitude technique,

    (ii) Class A2 – Performance equivalent to or better than the use of the Multiple Amplitude Samples baseline technique, where at least 8 samples are taken for each Mode S bit position and are used in the decision process, and

    (iii) Class A3 – Performance equivalent to or better than the use of the Multiple Amplitude Samples baseline technique, where at least 10 samples are taken for each Mode S bit position and are used in the decision process.

80. (1) A report assembler function shall include the message decoding, report assembly, and output interface sub-functions.

(2) When an extended squitter message is received, the message shall be decoded and the applicable ADS-B report of the types as provided under regulation 81 shall be generated within 0.5 seconds

81. (1) A State vector report shall contain —

(a) the time of applicability;

(b) information about an airborne or vehicle's current kinematic state such as position and velocity;

(c) the measure of the integrity of the navigation data, based on information received in airborne or ground position;

(d) the airborne velocity; and

(e) the identification and type extended squitter messages.

(2) The time of applicability shall be reported individually for the position related report parameters and the velocity related report parameters, due to separate messages used for the position and velocity.

(3) A State vector report shall include a time of applicability for the estimated position or estimated velocity information, not based on a message with updated position or velocity information, when such estimated position or velocity information is included in the State vector report.

(4) A mode status report shall, contain —

(a) time of applicability and current operational information about the transmitting participant, including airborne or vehicle address;

(b) call sign;

(c) ADS-B version number;

(d) airborne or vehicle length and width information;

(e) state vector quality information; and

(f) other information based on information received in operational status, airborne identification and type, airborne velocity and airborne status extended squitter messages.

(5) A report assembler function shall update the report time of applicability when a mode status report is generated.

(6) A parameter which do not have a valid data available shall, either be indicated as invalid or omitted from the mode status report.

(7) An air referenced velocity reports shall be generated when the air referenced velocity information is received in airborne velocity extended squitter messages.

(8) An air referenced velocity report shall, contain time of applicability, airspeed and heading information.

(9) Certain classes of extended squitter receiving systems, as defined in regulation 83 are required to generate air referenced velocity reports.

(10) When an individual mode status report is generated, the report assembly function shall update the report time of applicability.

(11) An RA report shall contain time of applicability and the contents of an active Airborne Collision Avoidance System resolution advisory as received in a Type=28 and Subtype=2 extended squitter message.

82. (1) When a TIS-B message is received by airborne receiving systems, the information shall be reported to client applications.

(2) When an individual TIS-B report is generated, the report assembly function shall update the report time of applicability to the current time.

(3) A received information elements, except the 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.

(4) An information content reported shall, be the same as the information content received.

(5) When a TIS-B position message is received, it is compared with tracks to determine whether it can be decoded into target position, correlated to an existing track.

(6) When the message in subregulation (5) is decoded into target position a report shall be generated within 0.5 seconds.

(7) The report under subregulation (6) shall contain —

(a) the received position information with a time of applicability;

(b) the most recently received velocity measurement with a time of applicability;

(c) the estimated position and velocity applicable to a common time of applicability, airborne or vehicle address; and

(d) all other information in the received message.

(8) The estimated values shall be based on the received position information and the track history of the target.

(9) When a TIS-B velocity message is received, if it is correlated to a complete track —

(a) a report shall be generated, within 0.5 seconds of the message reception; and

(b) the estimated values shall be based on the based on the received ground reference velocity information and track history of the target.

(10) The report in subregulation (9), shall —

(a) contain the received velocity information with a time of applicability;

(b) the estimated position and velocity applicable to a common time of applicability; and

(c) airborne or vehicle address, and all other information in the received message.

(11) The whole message content of any received TIS-B management message shall, be reported directly to the client applications.

(12) The contents of a received TIS-B management message shall, be reported bit-for-bit to the client applications.

(13) The information content reported shall, be the same as the information content received.

83. (1) 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.

(2) A receiving system intended to generate ADS-B or TIS-B reports based on the reception of surface position messages, airborne position messages, or TIS-B messages shall use General Navigation Satellite System 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 paragraph 1.1.2.8.6.2 set out Schedule 1, when the navigation uncertainty category is 8 or 9; or

    (*b*) version zero (0) ADS-B messages, as defined in paragraphs 1.1.2.8.6.2 and 1.1.2 8.7, set out Schedule 1 when the navigation integrity category is 10 or 11.

(3) A UTC measured time data shall have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

(4) For a receiving system not intended to generate ADS-B or TIS-B reports, based on reception of ADS-B or TIS-B messages meeting the NUC or NIC criteria as provided under subregulation (2), a non-precision time source shall be allowed.

(5) Where there is no appropriate precision time source available, the receiving system shall establish an appropriate internal clock or counter having a maximum clock cycle or count time of 20 milliseconds.

(6) A established cycle or clock count shall, have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

84. (1) The report assembler function associated with Type I Mode S extended squitter receiving systems, as defined in regulation 65, shall support that subset of ADS-B and TIS-B reports and report parameters, that are required by the specific client applications being served by that receiving system.

(2) The report assembler function associated with Type II receiving systems, as defined in regulation 65, shall generate ADS-B and TIS-B reports according to the class of the receiving system as provided under Table 3 – 4 set out in Schedule 3, when the prerequisite ADS-B or TIS-B messages are being received.

(3) The report assembler function associated with Mode S extended squitter ground receiving systems, as defined in regulation 65, shall support that subset of ADS-B reports and report parameters that are required by the specific client applications being served by that receiving system.

85. (1) The Mode S extended squitter receiving system shall provide interoperability with both version zero and version one extended squitter ADS-B message formats.

(2) The Mode S extended squitter receiving system shall upon acquiring a new ADS-B target, initially apply the decoding provisions applicable to version 0 ADS-B messages until or unless an operational status message is received indicating version one message format is in use.

(3) The Mode S extended squitter receiving system shall —

(a) decode the version number information conveyed in the operational status message; and

(b) apply the corresponding decoding rules, version 0 or version 1, for the decoding of the subsequent extended squitter ADS-B messages from that specific airborne or vehicle.

(4) The Mode S extended squitter receiving system shall ignore the contents of any message subfield defined as reserved.

PART VI — *Multi Lateration (MLAT) Systems*

86. (1) The radio frequency characteristics, structure and data contents of signals used in 1 090 MHz MLAT systems shall conform to the provisions of Schedule 1.

(2) An MLAT system used for air traffic surveillance shall be capable of determining aircraft position and identity.

(3) Where an MLAT system is equipped to decode additional position information contained in transmissions, it shall report such information separately from the aircraft position calculated based on Time difference of arrivals.

87. (1) The effective radiated power of active interrogators shall be reduced to the lowest value consistent with the operationally required range of each individual interrogator site.

(2) An active MLAT system shall not use active interrogations to obtain information that can be obtained by passive reception within each required update period.

(3) An active MLAT system consisting of a set of transmitters shall be considered as a single Mode S interrogator.

(4) The set of transmitters used by all active MLAT systems in any part of the airspace shall, not cause any transponder to be impacted such that its occupancy, because of the aggregate of all MLAT 1 030 MHz interrogations, is greater than two per cent at any time.

(5) An active MLAT systems shall not use Mode S All-Call interrogations.

88. The performance characteristics of the MLAT system used for air traffic surveillance shall be that the intended operational service can be satisfactorily supported.

PART VII – *Technical Requirements for Airborne Surveillance Applications*

89. (1) An Airborne Collision Avoidance System shall support a function to identify unambiguously each reference aircraft relevant to the application.

(2) An Airborne Collision Avoidance System shall support a function to monitor the movements and behavior of each reference aircraft relevant to the application.

(3) An Airborne Collision Avoidance System shall support a computational function to predict the future position of a reference aircraft beyond simple extrapolation.

90. (1) An Airborne Collision Avoidance System shall display only one track for each distinct aircraft on a given display.

(2) Where a track generated by ADS-B/TIS-B IN and a track generated by an Airborne Collision Avoidance System have been determined to belong to the same aircraft, the track generated by ADS-B/TIS-B IN shall be displayed.

(3) The display of the tracks shall, comply with the requirements of Airborne Collision Avoidance System traffic display.

PART VIII — *General Provisions*

91. (1) An Air Navigation Service Provider who wishes to be exempted from any requirement under these Regulations may apply to the Authority in writing.
(2) The application shall specify the time when the Air Navigation Service Provider is expected by the Authority to fully comply.

92. (1) A person who performs any function determined by these regulations directly or by contract, under the provisions of these Regulations may be tested for drug or alcohol usage.

(2) A person who refuses to submit to a test to indicate —
   (*a*) the percentage by weight of alcohol in the blood; or
   (*b*) the presence of narcotic drugs, marijuana, or depressant or stimulant drugs or substances in the body, when requested by a law enforcement officer or the Authority, or refuses to furnish or to authorise the release of the test results requested by the Authority shall —
      (i) be denied any licence, certificate, rating, qualification, or authorisation issued under these regulations for a period of up to one year from the date of that refusal, or
      (ii) have his or her licence, certificate, rating, qualification, or authorisation issued under these regulations suspended or revoked.

(3) Any person who is convicted for the violation of any local or national statute relating to the growing, processing, manufacture, sale, disposition, possession, transportation, or importation of narcotic drugs, marijuana, or depressant or stimulant drugs or substances, shall —
   (*a*) be denied any license, certificate, rating, qualification, or authorisation issued under these Regulations for a period of up to one year after the date of conviction; or
   (*b*) have his or her licence, certificate, rating, qualification, or authorisation issued under these Regulations suspended or revoked.

93. (1) An Air Navigation Service Provider holder of a certificate issued under these regulations, shall apply to the Authority for —
   (*a*) replacement of the certificate if lost or destroyed;
   (*b*) change of name on the certificate; or
   (*c*) an endorsement on the certificate.

(2) For purpose of subregulation (1), the holder of a certificate shall submit to the Authority - -
   (*a*) the original certificate, or a copy thereof in case of loss; and
   (*b*) a court order, or other legal document verifying the name change.

(3) The Authority shall return to the holder of a certificate, with the appropriate changes applied for, if any, the originals specified under subregulation (2) and, where necessary, retain copies thereof.

94. (1) A holder of a CNSP certificate issued under these Regulations shall notify the Authority of the change in the physical and mailing address within 14 days of such change.

(2) A holder of a CNSP certificate who does not notify the Authority of the change in the physical and mailing address within the time frame specified in subregulation (1), shall not exercise the privileges of the certificate.

95. A person shall apply to the Authority in Form A set out in Schedule 4 for replacement of documents issued under these Regulations if such documents are lost or destroyed.

96. (1) A person shall not —

   (*a*) use any certificate or exemption issued or required by or under these Regulations which has been forged, altered, cancelled, or suspended, or to which he is not entitled;

   (*b*) forge or alter any certificate or exemption issued or required by or under these Regulations;

   (*c*) lend any certificate or exemption issued or required by or under these Regulations to any other person;

   (*d*) make any false representation for the purpose of procuring for himself or any other person the grant, issue, renewal or variation of any such certificate or exemption; or

   (*e*) mutilate, alter, render illegible or destroy any records, or any entry made therein, required by or under these Regulations to be maintained, or knowingly make, or procure or assist in the making of, any false entry in any such record, or wilfully omit to make a material entry in such record.

(2) Any record required to be maintained by or under these Regulations shall be recorded in a permanent and indelible material.

(3) A person shall not issue any certificate or exemption under these Regulations unless he or she is authorised by the Authority.

(4) A person shall not issue any certificate referred to in subregulation (3), unless he or she has satisfied himself or herself that all statements in the certificate are correct, and that the applicant is qualified to hold that certificate.

97. (1) Any person who knows of a violation of these Regulations, rules, or orders issued there under, shall report it to the Authority.

(2) For purposes of subregulation (1), the Authority shall determine the nature and type of investigation or enforcement action that need to be taken.

98. Any person who fails to comply with any direction given to him or her by the Authority or by any authorised person under any provision of these Regulations shall be deemed for the purposes of these Regulations to have contravened that provision.

PART IX — *Offences and Penalties*

99. (1) A person who contravenes any provision of these Regulations, orders, notices or proclamations made there under is liable to a fine or imprisonment or both, and in the case of a continuing contravention, each day of the contravention shall constitute a separate offence.

(2) Any person who contravenes any provision of these Regulations is to be liable to a fine not exceeding P 100 000 or to imprisonment for a term not more than six months, or to both.

(3) If it is proved that an act or omission of any person, which would otherwise have been a contravention by that person of a provision of these Regulations, orders, notices or proclamations made under the Regulations was due to any cause not avoidable by the exercise of reasonable care by that person, the act or omission shall be deemed not to be a contravention by that person of that provision.

SCHEDULES

SCHEDULE 1

(Regs.: 14, 17-22, 24, 27, 38, 44, 47, 83 and 86)

1. Surveillance Systems

1.1 Secondary Surveillance Radar (SSR) System Characteristics

Note 1.— Section 1.1.1 prescribes the technical characteristics of SSR systems having only Mode A and Mode C capabilities. Section 1.1.2 prescribes the characteristics of systems with Mode S capabilities. Chapter 5 prescribes additional requirements on Mode S extended squitter.

Note 2.— Systems using Mode S capabilities are generally used for air traffic control surveillance systems. In addition, certain ATC applications may use Mode S emitters, example for vehicle surface surveillance or for fixed target detection on surveillance systems. Under such specific conditions, the term "aircraft" can be understood as "aircraft or vehicle (A/V)". While those applications may use a limited set of data, any deviation from standard physical characteristics must be considered very carefully by the appropriate authorities. They must consider not only their own surveillance (SSR) environment but also possible effects on other systems like Airborne Collision Avoidance System.

Note 3.— Non-Standard-International alternative units are used as permitted by under regulation (5) of the Civil Aviation (Units of Measurements to be used in air and ground operations) Regulations, .

1.1.1 Systems having only Mode A and Mode C capabilities

Note 1.— In this section, SSR modes are designated by letters A and C. Suffixed letters, example A_2, C_4, are used to designate the individual pulses used in the air-to-ground pulse trains. This common use of letters is not to be construed as implying any particular association of modes and codes.

Note 2. — Provisions for the recording and retention of radar data are contained under in Civil Aviation (Air Traffic Services), Regulations, Part VI.

1.1.1.1 Interrogation And Control (Interrogation Side-Lobe Suppression) Radio Frequencies (Ground-To-Air)

1.1.1.1.1 The carrier frequency of the interrogation and control transmissions shall be 1 030 MHz.

1.1.1.1.2   The frequency tolerance shall be plus or minus 0.2 MHz.

1.1.1.1.3   The carrier frequencies of the control transmission and of each of the interrogation pulse transmissions shall not differ from each other by more than 0.2 MHz.

1.1.1.2   Reply Carrier Frequency (Air-To-Ground)

1.1.1.2.1   The carrier frequency of the reply transmission shall be 1 090 MHz.

1.1.1.2.2   The frequency tolerance shall be plus or minus 3 MHz.

1.1.1.3   Polarization

Polarization of the interrogation, control and reply transmissions shall be predominantly vertical.

1.1.1.4   Interrogation Modes (Signals-In-Space)

1.1.1.4.1   The interrogation shall consist of two transmitted pulses designated P_1 and P_3. A control pulse P_2 shall be transmitted following the first interrogation pulse P_1.

1.1.1.4.2   Interrogation Modes A and C shall be as defined in 1.1.1.4.3.

1.1.1.4.3   The interval between P_1 and P_3 shall determine the mode of interrogation and shall be as follows –

Mode A   8 ±0.2 microseconds
Mode C   21 ±0.2 microseconds

1.1.1.4.4   The interval between P_1 and P_2 shall be 2.0 plus or minus 0.15 microseconds.

1.1.1.4.5   The duration of pulses P_1, P_2 and P_3 shall be 0.8 plus or minus 0.1 microsecond.

1.1.1.4.6   The rise time of pulses P_1, P_2 and P_3 shall be between 0.05 and 0.1 microsecond.

Note 1.-The definitions are contained in Figure 1-1 "Definitions of secondary surveillance radar waveform shapes, intervals and the reference point for sensitivity and power".

Note 2.-The intent of the lower limit of rise time (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no

greater than that which, theoretically, would be produced by a trapezoidal wave having the stated rise time.

1.1.1.4.7   The decay time of pulses P_1, P_2 and P_3 shall be between 0.05 and 0.2 microsecond.

Note. - The intent of the lower limit of decay time (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no greater than that which, theoretically, would be produced by a trapezoidal wave having the stated decay time.

1.1.1.5   Interrogator And Control Transmission Characteristics (Interrogation Side-Lobe Suppression — Signals-In-Space)

1.1.1.5.1   The radiated amplitude of P_2 at the antenna of the transponder shall be –

(a) equal to or greater than the radiated amplitude of P_1 from the side-lobe transmissions of the antenna radiating P_1; and

(b) at a level lower than 9 dB below the radiated amplitude of P_1, within the desired arc of interrogation.

1.1.1.5.2   Within the desired beam width of the directional interrogation (main lobe), the radiated amplitude of P_3 shall be within 1 dB of the radiated amplitude of P_1.

1.1.1.6   Reply Transmission Characteristics (Signals-In-Space)

1.1.1.6.1   *Framing pulses.* The reply function shall employ a signal comprising two framing pulses spaced 20.3 microseconds as the most elementary code.

1.1.1.6.2   Information Pulses

1.1.1.6.2.1   Information pulses shall be spaced in increments of 1.45 microseconds from the first framing pulse. The designation and position of these information pulses shall be as follows:

Pulses	Position (microseconds)
C_1	1.45
A_1	2.90
C_2	4.35
A_2	5.80
C_4	7.25

A_4	8.70
X	10.15
B_1	11.60
D_1	13.05
B_2	14.50
D_2	15.95
B_4	17.40
D_4	18.85

Note. - The standard relating to the use of these pulses given in Regulation 20 (1) is contained in the Aeronautical Surveillance Manual *(Doc 9924)*

1.1.1.6.2.2 The position of the X pulse shall not be used in replies to Mode A or Mode C interrogations if the safe operation of surveillance systems cannot be maintained.

1.1.1.6.2.3 Utilization of the X pulse for special applications shall be carried out in conformance with a procedure established by the Authority to ensure compatibility of all systems.

1.1.1.6.3 *Special position identification pulse (SPI).* In addition to the information pulses provided, a special position identification pulse shall be transmitted but only as a result of manual (pilot) selection. When transmitted, it shall be spaced at an interval of 4.35 microseconds following the last framing pulse of Mode A replies only.

1.1.1.6.4 *Reply pulse shape.* All reply pulses shall have a pulse duration of 0.45 plus or minus 0.1 microsecond, a pulse rise time between 0.05 and 0.1 microsecond and a pulse decay time between 0.05 and 0.2 microsecond. The pulse amplitude variation of one pulse with respect to any other pulse in a reply train shall not exceed 1 dB.

Note.— The intent of the lower limit of rise and decay times (0.05 microsecond) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is not greater than that which, theoretically, would be produced by a trapezoidal wave having the stated rise and decay times.

1.1.1.6.5 *Reply pulse position tolerances.* The pulse spacing tolerance for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group shall be plus or minus 0.10 microsecond. The pulse interval tolerance of the special position identification pulse with respect to the last framing pulse of the reply group shall be plus or minus 0.10 microsecond. The pulse spacing tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) shall not exceed plus or minus 0.15 microsecond.

1.1.1.6.6 *Code nomenclature.* The code designation shall consist of digits between 0 and 7 inclusive, and shall consist of the sum of the subscripts of the pulse numbers given in 1.1.1.6.2 above, employed as follows:

Digit	Pulse Group
First (most significant)	A
Second	B
Third	C
Fourth	D

1.1.1.7 Technical Characteristics of Transponders with Mode A And Mode C Capabilities Only

1.1.1.7.1 *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 P_3 is in excess of a level 1 dB below the received amplitude of P_1 but no greater than 3 dB above the received amplitude of P_1;

(b) either no pulse is received in the interval 1.3 microseconds to 2.7 microseconds after P_1, or P_1 exceeds by more than 9 dB any pulse received in this interval; and

(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 P_1, P_2 or P_3.

1.1.1.7.2 The transponder shall not reply under the following conditions —

(a) to interrogations when the interval between pulses P_1 and P_3 differs from those specified in 1.1.1.4.3 by more than plus or minus 1.0 microsecond; and

(b) upon receipt of any single pulse which has no amplitude variations approximating a normal interrogation condition.

1.1.1.7.3 *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.

1.1.1.7.4 Suppression

Note.— This characteristic is used to prevent replies to interrogations received via the side lobes of the interrogator antenna, and to prevent Mode A/C transponders from replying to Mode S interrogations.

1.1.1.7.4.1 The transponder shall be suppressed when the received amplitude of P_2 is equal to, or in excess of, the received amplitude of P_1 and spaced 2.0 plus or minus 0.15 microseconds. The detection of P_3 is not required as a prerequisite for initiation of suppression action.

1.1.1.7.4.2 The transponder suppression shall be for a period of 35 plus or minus 10 microseconds.

1.1.1.7.4.2.1 The suppression shall be capable of being reinitiated for the full duration within 2 microseconds after the end of any suppression period.

1.1.1.7.4.3 Suppression in presence of S_1 pulse

Note.— The S_1 pulse is used in a technique employed by Airborne Collision Avoidance System known as "whisper-shout" to facilitate Airborne Collision Avoidance System surveillance of Mode A/C aircraft in higher traffic densities. The whisper-shout technique is explained in the Airborne Collision Avoidance System (Airborne Collision Avoidance System) Manual (Doc 9863).

When an S_1 pulse is detected 2.0 plus or minus 0.15 microseconds before the P_1 of a Mode A or Mode C interrogation –

(a)   with S_1 and P_1 above MTL, the transponder shall be suppressed as specified in 1.1.1.7.4.1;

(b)   with P_1 at MTL and S_1 at MTL, the transponder shall be suppressed and shall reply to no more than 10 per cent of Mode A/C interrogations;

(c)   with P_1 at MTL and S_1 at MTL –3 dB, the transponder shall reply to Mode A/C interrogations at least 70 per cent of the time; or

(d)   with P_1 at MTL and S_1 at MTL –6 dB, the transponder shall reply to Mode A/C interrogations at least 90 per cent of the time.

Note 1.— The suppression action is because of the detection of S_1 and P_1 and does not require detection of a P_2 or P_3 pulse.

Note 2.— S_1 has a lower amplitude than P_1. Certain Airborne Collision Avoidance System use this mechanism to improve target detection (4.3.7.1).

Note 3.— These requirements also apply to a Mode A/C only capable transponder when an S_1 precedes an intermode interrogation (2.1.2.1).

1.1.1.7.5   Receiver Sensitivity and Dynamic Range

1.1.1.7.5.1 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; or

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

1.1.1.7.5.2   The reply and suppression characteristics shall apply over a received amplitude of P_1 between minimum triggering level and 50 dB above that level.

1.1.1.7.5.3   The variation of the minimum triggering level between modes shall not exceed 1 dB for nominal pulse spacings and pulse widths.

1.1.1.7.6   *Pulse duration discrimination.* Signals of received amplitude between minimum triggering level and 6 dB above this level, and of a duration less than 0.3 microsecond, shall not cause the transponder to initiate reply or suppression action. 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 over the signal amplitude range of minimum triggering level (MTL) to 50 dB above that level.

1.1.1.7.7   *Echo suppression and recovery.* The transponder shall contain an echo suppression facility designed to permit normal operation in the presence of echoes of signals-in-space. The provision of this facility shall be compatible with the requirements for suppression of side lobes given in 1.1.1.7.4.1.

1.1.1.7.7.1   *Desensitization.* Upon receipt of any pulse more than 0.7 microsecond in duration, the receiver shall be desensitized by an amount that is within at least 9 dB of the amplitude of the desensitizing pulse but shall at no time exceed the amplitude of the desensitizing pulse, with the exception of possible overshoot during the first microsecond following the desensitizing pulse.

Note.— Single pulses of duration less than 0.7 microsecond are not required to cause the specified desensitization nor to cause desensitization of duration greater than permitted by 1.1.1.7.7.1 and 1.1.1.7.7.2.

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

1.1.1.7.8   *Random 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 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.

1.1.1.7.8.1   *Random triggering rate in the presence of low-level in-band continuous wave (CW) interference.* The total random trigger rate on all Mode A 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.

1.1.1.7.9   Reply Rate

1.1.1.7.9.1   All transponders shall be capable of continuously generating at least 500 replies per second for a 15-pulse coded reply. Transponder installations used solely below 4 500 m (15 000 ft), or below a lesser altitude established by the appropriate authority or by regional air navigation agreement, and in aircraft with a maximum cruising true airspeed not exceeding 175 kt (324 km/h) shall be capable of generating at least 1 000 15-pulse coded replies per second for a duration of 100 milliseconds. Transponder installations operated above 4 500 m (15 000 ft) or in aircraft with a maximum cruising true airspeed in excess of 175 kt (324 km/h), shall be capable of generating at least 1 200 15-pulse coded replies per second for a duration of 100 milliseconds.

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

Note 2.— The reply rate requirement of 500 replies per second establishes the minimum continuous reply rate capability of the transponder. As per the altitude and speed criteria above, the 100 or 120 replies in a 100-millisecond interval defines the peak capability of the transponder. The transponder must be capable of replying to this short-term burst rate, even though the

transponder may not be capable of sustaining this rate. If the transponder is subjected to interrogation rates beyond its reply rate capability, the reply rate limit control of 1.1.1.7.9.2 acts to gracefully desensitize the transponder in a manner that favours closer interrogators. Desensitization eliminates weaker interrogation signals.

1.1.1.7.9.2 *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 shall permit adjustment, as a minimum, to any value between 500 and 2 000 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.

1.1.1.7.10 *Reply delay and jitter.* The time delay between the arrival, at the transponder receiver, of the leading edge of P_3 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 P_3, shall not exceed 0.1 microsecond for receiver input levels between 3 dB and 50 dB above minimum triggering level. Delay variations between modes on which the transponder is capable of replying shall not exceed 0.2 microsecond.

1.1.1.7.11 Transponder Power Output and Duty Cycle

1.1.1.7.11.1 The peak pulse power available at the antenna end of the transmission line of the transponder shall be at least 21 dB and not more than 27 dB above 1 W, except that for transponder installations used solely below 4 500 m (15 000 ft), or below a lesser altitude established by the appropriate authority or by regional air navigation agreement, a peak pulse power available at the antenna end of the transmission line of the transponder of at least 18.5 dB and not more than 27 dB above 1 W shall be permitted.

Note.— An extended squitter non-transponder device on an aerodrome surface vehicle may operate with a lower minimum power output as specified Regulation in 67 (2).

1.1.1.7.11.2 *Recommendation.*— The peak pulse power specified in 1.1.1.7.11.1 should be maintained over a range of replies from code 0000 at a rate of 400 replies per second to a maximum pulse content at a rate of 1 200 replies per second or a maximum value below 1 200 replies per second of which the transponder is capable.

1.1.1.7.12   Reply Codes

1.1.1.7.12.1   *Identification.* The reply to a Mode A interrogation shall consist of the two framing pulses specified in 1.1.1.6.1 together with the information pulses (Mode A code) specified in 1.1.1.6.2.

Note.— The Mode A code designation is a sequence of four digits in accordance with 1.1.1.6.6.

1.1.1.7.12.1.1   The Mode A code shall be manually selected from the 4 096 codes available.

1.1.1.7.12.2   *Pressure-altitude transmission.* The reply to Mode C interrogation shall consist of the two framing pulses specified in 1.1.1.6.1 above. When digitized pressure-altitude information is available, the information pulses specified in 1.1.1.6.2 shall also be transmitted.

1.1.1.7.12.2.1   Transponders shall be provided with means to remove the information pulses but to retain the framing pulses when the provision of 1.1.1.7.12.2.4 below is not complied with in reply to Mode C interrogation.

1.1.1.7.12.2.2   The information pulses shall be automatically selected by an analog-to-digital converter connected to a pressure-altitude data source in the aircraft referenced to the standard pressure setting of 1 013.25 hectopascals.

Note.— The pressure setting of 1 013.25 hectopascals is equal to 29.92 inches of mercury.

1.1.1.7.12.2.3   Pressure-altitude shall be reported in 100-ft increments by selection of pulses as shown in the Appendix to this chapter.

1.1.1.7.12.2.4   The digitizer code selected shall correspond to within plus or minus 38.1 m (125 ft), on a 95 per cent probability basis, with the pressure-altitude information (referenced to the standard pressure setting of 1 013.25 hectopascals), used on board the aircraft to adhere to the assigned flight profile.

1.1.1.7.13   *Transmission of the special position identification (SPI) pulse.* When required, this pulse shall be transmitted with Mode A replies, as specified in 1.1.1.6.3, for a period of between 15 and 30 seconds.

1.1.1.7.14   Antenna

1.1.1.7.14.1   The transponder antenna system, when installed on an aircraft, shall have a radiation pattern which is essentially omnidirectional in the horizontal plane.

1.1.1.7.14.2 The vertical radiation pattern should be nominally equivalent to that of a quarterwave monopole on a ground plane.

1.1.1.8 Technical Characteristics of Ground Interrogators With Mode A And Mode C Capabilities only

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

1.1.1.8.1.1 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.

1.1.1.8.2 Radiated Power

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.

1.1.1.8.3 When Mode C information is to be used from aircraft flying below transition levels, the altimeter pressure reference datum shall be considered.

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

1.1.1.9 Interrogator Radiated Field Pattern

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

1.1.1.10 Interrogator Monitor

1.1.1.10.1 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.

1.1.1.10.2   In addition to range and azimuth monitoring, provision shall 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.

1.1.1.11   Spurious Emissions and Spurious Responses

1.1.1.11.1   Spurious Radiation

CW radiation shall not exceed 76 dB below 1 W for the interrogator and 70 dB below 1 W for the transponder.

1.1.1.11.2   Spurious Responses

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

1.1.2   SYSTEMS HAVING MODE S CAPABILITIES

1.1.2.1   *Interrogation signals-in-space characteristics.* The paragraphs herein describe the signals-in-space as they can be expected to appear at the antenna of the transponder.

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 1.1.2.11.4.

1.1.2.1.1   *Interrogation carrier frequency.* The carrier frequency of all interrogations (uplink transmissions) from ground facilities with Mode S capabilities shall be 1 030 plus or minus 0.01 MHz.

1.1.2.1.2   *Interrogation spectrum.* The spectrum of a Mode S interrogation about the carrier frequency shall not exceed the limits specified in Figure 1-2 set out in Schedule 1.

Note.— The Mode S interrogation spectrum is data dependent. The broadest spectrum is generated by an interrogation that contains all binary ONEs.

1.1.2.1.3   *Polarization.* Polarization of the interrogation and control transmissions shall be nominally vertical.

1.1.2.1.4   *Modulation.* For Mode S interrogations, the carrier frequency shall be pulse modulated. In addition, the data pulse, *P6*, shall have internal phase modulation.

1.1.2.1.4.1 *Pulse modulation.* Intermode and Mode S interrogations shall consist of a sequence of pulses as specified in 1.1.2.1.5 and Tables 1-1, 1-2, 1-3, and 1- 4 as provided for in Schedule 1.

Note.— 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 1.1.1.4

1.1.2.1.4.2 *Phase modulation.* The short (16.25-microsecond) and long (30.25-microsecond) P6 pulses of 1.1.2.1.4.1 shall have internal binary differential phase modulation consisting of 180-degree phase reversals of the carrier at a 4 megabit per second rate.

1.1.2.1.4.2.1 *Phase reversal duration.* The duration of the phase reversal shall be less than 0.08 microsecond and the phase shall advance (or retard) monotonically throughout the transition region. There shall be no amplitude modulation applied during the phase transition.

Note.- The minimum duration of the phase reversal is not specified. Nonetheless, the spectrum requirements of 1.1.2.1.2 must be met.

1.1.2.1.4.2.2 *Phase relationship.* The tolerance on the 0 and 180-degree phase relationship between successive chips and on the sync phase reversal (1.1.5.2.2) within the P6 pulse shall be plus or minus 5 degrees.

Note.— In Mode S a "chip" is the 0.25 microsecond carrier interval between possible data phase reversals.

1.1.2.1.5 Pulse and phase reversal sequences. Specific sequences of the pulses or phase reversals described in 1.1.2.1.4 shall constitute interrogations.

1.1.2.1.5.1 Intermode interrogation

1.1.2.1.5.1.1 *Mode A/C/S all-call interrogation.* This interrogation shall consist of three pulses: P1, P3, and the long P4 as shown in Figure 1-3. One or two control pulses (P2 alone, or P1 and P2) shall be transmitted using a separate antenna pattern to suppress responses from aircraft in the side lobes of the interrogator antenna.

Note.— The Mode A/C/S all-call interrogation elicits a Mode A or Mode C reply (depending on the P1-P3 pulse spacing) from a Mode A/C transponder because it does not recognize the P4 pulse. A Mode S transponder recognizes the long P4 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. 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. This interrogation cannot be used with stochastic/lockout override, since probability of reply cannot be specified.

1.1.2.1.5.1.1.1   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.

1.1.2.1.5.1.2   *Mode A/C-only all-call interrogation.* This interrogation shall be identical to that of the Mode A/C/S all-call interrogation except that the short *P4* pulse shall be used.

Note.— 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 P4 pulse and does not reply to this interrogation

1.1.2.1.5.1.3   *Pulse intervals.* The pulse intervals between *P1*, *P2* and *P3* shall be as defined in 1.1.1.4.3 and 1.1.1.4.4. The pulse interval between *P3* and *P4* shall be 2 plus or minus 0.05 microsecond.

1.1.2.1.5.1.4   *Pulse amplitudes.* Relative amplitudes between pulses *P1*, *P2* and *P3* shall be in accordance with 1.1.1.5. The amplitude of *P4* shall be within 1 dB of the amplitude of *P3*.

1.1.2.1.5.2   *Mode S interrogation.* The Mode S interrogation shall consist of three pulses: *P1*, *P2* and *P6* as shown in Figure 1 - 4 as provided in the Schedule 1.

Note.— 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.

1.1.2.1.5.2.1 *Mode S side-lobe suppression.* The *P5* pulse shall be used with the Mode S-only all-call interrogation (UF = 11, see 1.5.2) to prevent replies from aircraft in the side and back lobes of the antenna (1.1.5.2.5). When used, *P5* shall be transmitted using a separate antenna pattern.

Note 1.— The action of *P5* is automatic. Its presence, if of sufficient amplitude at the receiving location, masks the sync phase reversal of *P6*.

Note 2.— The *P5* pulse may be used with other Mode S interrogations.

1.1.2.1.5.2.2 *Sync phase reversal.* The first phase reversal in the *P6* pulse shall be the sync phase reversal. It shall be the timing reference for subsequent transponder operations related to the interrogation.

1.1.2.1.5.2.3 *Data phase reversals.* Each data phase reversal shall occur only at a time interval (N times 0.25) plus or minus 0.02 microsecond (N equal to, or greater than 2) after the sync phase reversal. The 16.25-microsecond *P6* pulse shall contain at most 56 data phase reversals. The 30.25-microsecond *P6* pulse shall contain at most 112 data phase reversals. The last chip, that is the 0.25-microsecond time interval following the last data phase reversal position, shall be followed by a 0.5-microsecond guard interval.

Note.— The 0.5-microsecond guard interval following the last chip prevents the trailing edge of *P6* from interfering with the demodulation process.

1.1.2.1.5.2.4 *Intervals.* The pulse interval between *P1* and *P2* shall be 2 plus or minus 0.05 microsecond. The interval between the leading edge of *P2* and the sync phase reversal of *P6* shall be 2.75 plus or minus 0.05 microsecond. The leading edge of *P6* shall occur 1.25 plus or minus 0.05 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 0.05 microsecond before the sync phase reversal.

1.1.2.1.5.2.5 *Pulse amplitudes.* The amplitude of *P2* and the amplitude of the first microsecond of *P6* shall be greater than the amplitude of *P1* minus 0.25 dB. Exclusive of the amplitude transients associated with phase reversals, the amplitude variation of *P6* shall be less than 1 dB and the amplitude variation between successive chips in *P6* shall be less than 0.25 dB. The radiated amplitude of *P5* at the antenna of the transponder shall be –

(a) equal to or greater than the radiated amplitude of *P6* from the side-lobe transmissions of the antenna radiating *P6*; and

(b) at a level lower than 9 dB below the radiated amplitude of *P6* within the desired arc of interrogation.

1.1.2.2   Reply Signals-in-Space Characteristics

1.1.2.2.1   *Reply carrier frequency.* The carrier frequency of all replies (downlink transmissions) from transponders with Mode S capabilities shall be 1 090 plus or minus 1 MHz.

1.1.2.2.2   *Reply spectrum.* The spectrum of a Mode S reply about the carrier frequency shall not exceed the limits specified in Figure 1-5 in Schedule 1.

1.1.2.2.3   *Polarization.* Polarization of the reply transmissions shall be nominally vertical.

1.1.2.2.4   *Modulation.* The Mode S reply shall consist of a preamble and a data block. The preamble shall be a 4-pulse sequence and the data block shall be binary pulse-position modulated at a 1 megabit per second data rate.

1.1.2.2.4.1   *Pulse shapes.* Pulse shapes shall be as defined in Table 1-2 in Schedule 1. All values are in microseconds.

1.1.2.2.5   *Mode S reply.* The Mode S reply shall be as shown in Figure 1-6 in Schedule 1. The data block in Mode S replies shall consist of either 56 or 112 information bits.

1.1.2.2.5.1   *Pulse intervals.* All reply pulses shall start at a defined multiple of 0.5 microsecond from the first transmitted pulse. The tolerance in all cases shall be plus or minus 0.05 microsecond.

1.1.2.2.5.1.1   *Reply preamble.* The preamble shall consist of four pulses, each with a duration of 0.5 microsecond. The pulse intervals from the first transmitted pulse to the second, third and fourth transmitted pulses shall be 1, 3.5 and 4.5 microseconds, respectively.

1.1.2.2.5.1.2   *Reply data pulses.* The reply data block shall begin 8 microseconds after the leading edge of the first transmitted pulse. Either 56 or 112 one-microsecond bit intervals shall be assigned to each transmission. A 0.5-microsecond pulse shall be transmitted either in the first or in the second half of each interval. When a pulse transmitted in the second half of one interval is followed by another pulse transmitted in the first half of the next interval, the two pulses merge and a one-microsecond pulse shall be transmitted.

1.1.2.2.5.2   *Pulse amplitudes.* The pulse amplitude variation between one pulse and any other pulse in a Mode S reply shall not exceed 2 dB.

1.1.2.3   Mode S Data Structure

1.1.2.3.1   Data Encoding

1.1.2.3.1.1   *Interrogation data.* The interrogation data block shall consist of the sequence of 56 or 112 data chips positioned after the data phase reversals within P6 (1.1.5.2.3). A 180-degree carrier phase reversal preceding a chip shall characterize that chip as a binary ONE. The absence of a preceding phase reversal shall denote a binary ZERO.

1.1.2.3.1.2   *Reply 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 1.1.2.5.1.2. 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.

1.1.2.3.1.3   *Bit numbering.* The bits shall be numbered in the order of their transmission, beginning with bit 1. Unless otherwise stated, numerical values encoded by groups (fields) of bits shall be encoded using positive binary notation and the first bit transmitted shall be the most significant bit (MSB). Information shall be coded in fields which consist of at least one bit.

Note.— In the description of Mode S formats the decimal equivalent of the binary code formed by the bit sequence within a field is used as the designator of the field function or command.

1.1.2.3.2   Formats of Mode S Interrogations and Replies

Note.— A summary of all Mode S interrogation and reply formats is presented in Figures 1-7 and 1-8. A summary of all fields appearing in uplink and downlink formats is given in Table 1-1 and a summary of all subfields is given in Table 1-4 in Schedule 1.

1.1.2.3.2.1   *Essential fields.* Every Mode S transmission shall contain two essential fields. One is a descriptor which shall uniquely define the format of the transmission. This shall appear at the beginning of the transmission for all formats. The descriptors are designated by the UF (uplink format) or DF (downlink format) fields. The second essential field shall be a 24-bit field appearing at the end of each transmission and shall contain parity information. In all uplink and in currently

defined downlink formats parity information shall be overlaid either on the aircraft address (1.1.2.4.1.2.3.1) or on the interrogator identifier according to 1.1.2.3.3.2. The designators are AP (address/parity) or PI (parity/interrogator identifier).

Note.— The remaining coding space is used to transmit the mission fields. For specific functions, a specific set of mission fields is determined. Mode S mission fields have two-letter designators. Subfields may appear within mission fields. Mode S subfields are labelled with three-letter designators.

1.1.2.3.2.1.1 *UF: Uplink format.* This uplink format field (5 bits long except in format 24 where it is 2 bits long) shall serve as the uplink format descriptor in all Mode S interrogations and shall be coded according to Figure 1-7 in Schedule 1.

1.1.2.3.2.1.2 *DF: Downlink format.* This downlink format field (5 bits long except in format 24 where it is 2 bits long) shall serve as the downlink format descriptor in all Mode S replies and shall be coded according to Figure 1-8 in Schedule 1.

1.1.2.3.2.1.3 *AP: Address/parity.* This 24-bit (33-56 or 89-112) field shall appear in all uplink and currently defined downlink formats except the Mode S-only all-call reply, DF = 11. The field shall contain parity overlaid on the aircraft address according to 1.1.2.3.3.2.

1.1.2.3.2.1.4 *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 1.1.2.3.3.2 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 in field (1.5.2.1.3) and IC field (1.5.2.1.2) equal to 0 or is an acquisition or an extended squitter (1.8.5, 1.8.6 or 1.8.7), the II and the SI codes shall be 0.

1.1.2.3.2.1.5 *DP: Data parity.* This 24-bit (89-112) downlink field shall contain the parity overlaid on a "Modified AA" field which is established by performing a modulo-2 summation (e.g. Exclusive-Or function) of the discrete address most significant 8 bits and BDS1, BDS2, where BDS1 (1.1.2.6.11.2.2) and BDS2 (1.1.2.6.11.2.3) are provided by the "RR" (1.1.2.6.1.2) and "RRS" (1.1.2.6.1.4.1) as specified in 1.1.2.6.11.2.2 and 1.1.2.6.11.2.3.

Example:

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

where "⊕" prescribes modulo-2 addition

The resulting "Modified AA" field then represents the 24-bit sequence (a1, a2...a24) that shall be used to generate the DP field in accordance with paragraph 1.1.2.3.3.2.

1.1.2.3.2.2 *Unassigned coding space.* Unassigned coding space shall contain all ZEROs as transmitted by interrogators and transponders.

Note.— Certain coding space indicated as unassigned in this section is reserved for other applications such as Airborne Collision Avoidance System, data link, etc.

1.1.2.3.2.3 *Zero and unassigned codes.* A zero code assignment in all defined fields shall indicate that no action is required by the field. In addition, codes not assigned within the fields shall indicate that no action is required.

Note.— The provisions of 1.1.2.3.2.2 and 1.1.2.3.2.3 ensure that future assignments of previously unassigned coding space will not result in ambiguity. That is, Mode S equipment in which the new coding has not been implemented will clearly indicate that no information is being transmitted in newly assigned coding space.

1.1.2.3.2.4 *Formats reserved for military use.* The Authority shall ensure that uplink formats are only used for selectively addressed interrogations and that transmissions of uplink or downlink formats do not exceed the RF power, interrogation rate, reply rate and squitter rate requirements of these regulations.

1.1.2.3.2.4.1 Through investigation and validation, the Authority shall ensure that military applications do not unduly affect the existing 1 030/1 090 MHz civil aviation operations environment.

1.1.2.3.3 Error Protection

1.1.2.3.3.1 *Technique.* Parity check coding shall be used within Mode S interrogations and replies to provide protection against the occurrence of errors.

1.1.2.3.3.1.1 *Parity check sequence.* A sequence of 24 parity check bits shall be generated by the rule described in 1.1.2.3.3.1.2 and shall be incorporated into the field formed by the last 24 bits of all Mode S transmissions. The 24 parity check bits shall be combined with either the address coding or the interrogator identifier coding as described in 1.1.2.3.3.2. The resulting combination then forms either the AP (address/parity, 1.1.2.3.2.1.3) field or the PI (parity/interrogator identifier, 1.1.2.3.2.1.4) field.

1.1.2.3.3.1.2 *Parity check sequence generation.* The sequence of 24 parity bits (p_1, p_2, ...p_{24}) shall be generated from the sequence of information bits (m_1, m_2......m_k) where k

is 32 or 88 for short or long transmissions respectively. This shall be done by means of a code generated by the polynomial –

$$G(x) = 1 + x^3 + x^{10} + x^{12} + x^{13} + x^{14} + x^{15} + x^{16}$$

$$+ x^{17} + x^{18} + x^{19} + x^{20} + x^{21} + x^{22} + x^{23} + x^{24}$$

When by the application of binary polynomial algebra, $X^{24}[M(x)]$ is divided by $G(x)$ where the information sequence $M(x)$ is –

$$m_k + m_{k-1}x + m_{k-2}x^2 + ... + m_1x^{k-1}$$

the result is a quotient and a remainder $R(x)$ of degree less than 24. The bit sequence formed by this remainder represents the parity check sequence. Parity bit pi, for any i from 1 to 24, is the coefficient of x^{24-i} in $R(x)$.

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

1.1.2.3.3.2   *AP and PI field generation.* Different address parity sequences shall be used for the uplink and downlink.

Note.— The uplink sequence is appropriate for a transponder decoder implementation. The downlink sequence facilitates the use of error correction in downlink decoding.

The code used in uplink AP field generation shall be formed as specified below from either the aircraft address (1.1.2.4.1.2.3.1.1), the all-call address (1.1.2.4.1.2.3.1.2) or the broadcast address (1.1.2.4.1.2.3.1.3).

The code used in downlink AP field generation shall be formed directly from the sequence of 24 Mode S address bits $(a1, a2,..., a24)$, where ai is the i-th bit transmitted in the aircraft address (AA) field of an all-call reply (1.1.2.5.2.2.2). The code used in downlink PI field generation shall be formed by a sequence of 24 bits $(a1, a2,..., a24)$, where the first 17 bits are ZEROs, the next three bits are a replica of the code label (CL) field (1.1.2.5.2.1.3) and the last four bits are a replica of the interrogator code (IC) field (1.1.2.5.2.1.2).

Note.— The PI code is not used in uplink transmissions.

A modified sequence $(b1, b2,..., b24)$ shall be used for uplink AP field generation. Bit bi is the coefficient of X^{48-i} in the polynomial $G(x)A(x)$, where:

$$A(x) = a_1 x^{23} + a_2 x^{22} + ... + a_{24}$$

and $G(x)$ is as defined in 1.1.2.3.3.1.2.

In the aircraft address a_i shall be the i-th bit transmitted in the AA field of an all-call reply. In the all-call and broadcast addresses a_i shall equal 1 for all values of i.

1.1.2.3.3.2.1   *Uplink transmission order.* The sequence of bits transmitted in the uplink AP field is:

$$t_{k+1}, t_{k+2} ... t_{k+24}$$

where the bits are numbered in order of transmission, starting with $k + 1$.
In uplink transmissions –
$$t_{k+i} = b_i \oplus p_i$$

where "$\oplus$" prescribes modulo-2 addition: i equals 1 is the first bit transmitted in the AP field.

1.1.2.3.3.2.2   *Downlink transmission order.* The sequence of bits transmitted in the downlink AP and PI field is:

$$t_{k+1}, t_{k+2} ... t_{k+24}$$

where the bits are numbered in order of transmission, starting with $k + 1$. In downlink transmissions:

$$t_{k+i} = a_i \oplus p_i$$

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

1.1.2.4   General Interrogation-Reply Protocol

1.1.2.4.1   *Transponder transaction cycle.* A transponder transaction cycle shall begin when the SSR Mode S transponder has recognized an interrogation. The transponder shall then evaluate the interrogation and determine whether it shall be accepted. If accepted, it shall then process the received interrogation and generate a reply, if appropriate. The transaction cycle shall end when –

(a) any one of the necessary conditions for acceptance has not been met; or
(b) an interrogation has been accepted and the transponder has either –

(i) completed the processing of the accepted interrogation if no reply is required, or

(ii) completed the transmission of a reply.

A new transponder transaction cycle shall not begin until the previous cycle has ended.

1.1.2.4.1.1 *Interrogation recognition.* SSR Mode S transponders shall be capable of recognizing the following distinct types of interrogations –

(a) Modes A and C;

(b) Intermode; and
(c) Mode S.

Note.— The recognition process is dependent upon the signal input level and the specified dynamic range (1.10).

1.1.2.4.1.1.1 *Mode A and Mode C interrogation recognition.* A Mode A or Mode C interrogation shall be recognized when a $P1 - P3$ pulse pair meeting the requirements of 1.1.1.4 has been received, and the leading edge of a $P4$ pulse with an amplitude that is greater than a level 6 dB below the amplitude of $P3$ is not received within the interval from 1.7 to 2.3 microseconds following the leading edge of $P3$. If a $P1 - P2$ 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 (1.4.2). 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.

1.1.2.4.1.1.2 *Intermode interrogation recognition.* An intermode interrogation shall be recognized when a $P1 - P3 \cdot P4$ pulse triplet meeting the requirements of 1.1.5.1 is received. An interrogation shall not be recognized as an intermode interrogation if –

(a) the received amplitude of the pulse in the $P4$ position is smaller than 6 dB below the amplitude of $P3$;

(b) the pulse interval between $P3$ and $P4$ is larger than 2.3 microseconds or shorter than 1.7 microseconds;

(c) the received amplitude of $P1$ and $P3$ is between MTL and $- 45$ dBm and the pulse duration of $P1$ or $P3$ is less than 0.3 microsecond; or

(d) the transponder is in suppression.

If a *P1 – P2* suppression pair and a Mode A or Mode C intermode interrogation are recognized simultaneously the transponder shall be suppressed.

1.1.2.4.1.1.3 *Mode S interrogation recognition.* A Mode S interrogation shall be recognized when a *P6* pulse is received with a sync phase reversal within the interval from 1.20 to 1.30 microseconds following the leading edge of *P6*. A Mode S interrogation shall not be recognized if a sync phase reversal is not received within the interval from 1.05 to 1.45 microseconds following the leading edge of *P6*.

1.1.2.4.1.2 *Interrogation acceptance.* Recognition according to 1.1.2.4.1 shall be a prerequisite for acceptance of any interrogation.

1.1.2.4.1.2.1 *Mode A and Mode C interrogation acceptance.* Mode A and Mode C interrogations shall be accepted when recognized (1.1.2.4.1.1.1).

1.1.2.4.1.2.2 Intermode interrogation acceptance

1.1.2.4.1.2.2.1 *Mode A/C/S all-call interrogation acceptance.* A Mode A/C/S all-call interrogation shall be accepted if the trailing edge of *P4* is received within 3.45 to 3.75 microseconds following the leading edge of *P3* and no lockout condition (1.1.2.6.9) prevents acceptance. A Mode A/C/S all-call shall not be accepted if the trailing edge of *P4* is received earlier than 3.3 or later than 4.2 microseconds following the leading edge of *P3*, or if a lockout condition (1.1.2.6.9) prevents acceptance.

1.1.2.4.1.2.2.2 *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 P4 pulse having a trailing edge following the leading edge of P3 by less than 3.3 microseconds.

1.1.2.4.1.2.3 *Mode S interrogation acceptance.* A Mode S interrogation shall only be accepted if –

   (a) the transponder is capable of processing the uplink format (UF) of the interrogation;

   (b) the address of the interrogation matches one of the addresses as defined in 1.1.2.4.1.2.3.1 implying that parity is established, as defined in 1.1.2.3.3;

(c) in the case of an all-call interrogation, no all-call lockout condition applies, as defined in 1.1.2.6.9; and

(d) the transponder can process the uplinked data of a long air-air surveillance (Airborne Collision Avoidance System) interrogation (UF-16) and presenting it at an output interface as contained in 1.1.2.10.5.2.2.1.

Note.— A Mode S interrogation may be accepted if the conditions specified in 1.1.2.4.1.2.3 a) and b) are met and the transponder is not capable of both processing the uplinked data of a Comm-A interrogation (UF=20 and 21) and presenting it at an output interface as provided for in 1.1.2.10.5.2.2.1.

1.1.2.4.1.2.3.1   *Addresses.* Mode S interrogations shall contain either –

(a) aircraft address; or

(b) the all-call address; or

(c) the broadcast address.

1.1.2.4.1.2.3.1.1   *Aircraft address.* If the aircraft's address is identical to the address extracted from a received interrogation according to the procedure of 1.1.2.3.3.2 and 1.1.2.3.3.2.1, the extracted address shall be considered correct for purposes of Mode S interrogation acceptance.

1.1.2.4.1.2.3.1.2   *All-call address.* A Mode S-only all-call interrogation (uplink format UF = 11) shall contain an address, designated the all-call address, consisting of twenty-four consecutive ONEs. If the all-call address is extracted from a received interrogation with format UF = 11 according to the procedure of 1.1.2.3.3.2 and 1.1.2.3.3.2.1, the address shall be considered correct for Mode S-only all-call interrogation acceptance.

1.1.2.4.1.2.3.1.3   *Broadcast address.* To broadcast a message to all Mode S transponders within the interrogator beam, a Mode S interrogation uplink format 20 or 21 shall be used and an address of twenty-four consecutive ONEs shall be substituted for the aircraft address. If the UF code is 20 or 21 and this broadcast address is extracted from a received interrogation according to the procedure of 1.1.2.3.3.2 and 1.1.2.3.3.2.1, the address shall be considered correct for Mode S broadcast interrogation acceptance.

Note.— Transponders associated with airborne collision avoidance systems also accept a broadcast with UF = 16.

1.1.2.4.1.3 *Transponder replies.* Mode S transponders shall transmit the following reply types --

  (a) Mode A and Mode C replies; and

  (b) Mode S replies.

1.1.2.4.1.3.1 *Mode A and Mode C replies.* A Mode A (Mode C) reply shall be transmitted as specified in 1.1.1.6 when a Mode A (Mode C) interrogation has been accepted.

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

1.1.2.4.1.3.2.1 *Replies to intermode interrogations.* A Mode S reply with downlink format 11 shall be transmitted in accordance with the provisions of 1.1.2.5.2.2 when a Mode A/C/S all-call interrogation has been accepted.

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

1.1.2.4.1.3.2.2 *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 1-5 provided in Schedule 1.

  Note.— Four categories of Mode S replies may be transmitted in response to Mode S interrogations --

  (a) Mode S all-call replies (DF = 11);

  (b) surveillance and standard-length communications replies (DF = 4, 5, 20 and 21);

  (c) extended length communications replies (DF = 24); and

  (d) air-air surveillance replies (DF = 0 and 16).

1.1.2.4.1.3.2.2.1 *Replies to SSR Mode S-only all-call interrogations.* The downlink format of the reply to a Mode S-only 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 1.1.2.5.

Note.— A Mode S reply may or may not be transmitted when a Mode S interrogation with UF = 11 has been accepted.

1.1.2.4.1.3.2.2.2 *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 1.1.2.6.

Note.— If a Mode S interrogation with UF = 20 or 21 and a broadcast address is accepted, no reply is transmitted (1.1.2.4.1.2.3.1.3).

1.1.2.4.1.3.2.2.3 *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 1.1.2.7.

1.1.2.4.1.3.2.2.4 *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 1.1.2.8.

1.1.2.4.2 SUPPRESSION

1.1.2.4.2.1 *Effects of suppression.* A transponder in suppression (1.1.1.7.4) 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.

1.1.2.4.2.2 *Suppression pairs.* The two-pulse Mode A/C suppression pair defined in 1.1.1.7.4.1 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 P3 – P4 pair of the Mode A/C-only all-call interrogation both prevents a reply and initiates suppression. Likewise, the P1 – P2 preamble of a Mode S interrogation initiates suppression independently of the waveform that follows it.

1.1.2.4.2.3 Suppression in presence of *S1* pulse shall be as defined in 1.1.1.7.4.3.

1.1.2.5 INTERMODE AND MODE S ALL-CALL TRANSACTIONS

1.1.2.5.1   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 1.1.2.5.1 and the corresponding interrogation-reply protocols are defined in 1.1.2.4.

1.1.2.5.2   MODE S-ONLY All-Call Transactions

> Note.— These transactions allow the ground to acquire Mode S aircraft by use of an interrogation addressed to all Mode S-equipped aircraft. The reply is via downlink format 11 which returns the aircraft address. The interrogation-reply protocols are defined in 1.1.2.4

1.1.2.5.2.1 Mode S-only all-call interrogation, uplink format 11
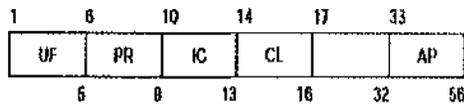
The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format	3.1.2.3.2.1.1
PR probability of reply	3.1.2.5.2.1.1
IC interrogator code	3.1.2.5.2.1.2
CL code label	3.1.2.5.2.1.3
spare — 16 bits	
AP address/parity	3.1.2.3.2.1.3

1.1.2.5.2.1.1   *PR: Probability of reply.* This 4-bit (6-9) uplink field shall contain commands to the transponder specifying the probability of reply to that interrogation (1.1.2.5.4). Codes are as follows -

0	signifies reply with probability of 1
1	signifies reply with probability of 1/2
2	signifies reply with probability of 1/4
3	signifies reply with probability of 1/8
4	signifies reply with probability of 1/16
5, 6, 7	not assigned
8	signifies disregard lockout, reply with probability of 1
9	signifies disregard lockout, reply with probability of 1/2
10	signifies disregard lockout, reply with probability of 1/4
11	signifies disregard lockout, reply with probability of 1/8
12	signifies disregard lockout, reply with probability of 1/16
13, 14, 15	not assigned.

.

1.1.2.5.2.1.2   *IC: Interrogator code.* This 4-bit (10-13) uplink field shall contain either the 4-bit interrogator identifier code (1.1.2.5.2.1.2.3) or the lower 4 bits of the 6-bit surveillance identifier code (1.1.2.5.2.1.2.4) depending on the value of the CL field (1.1.2.5.2.1.3).

1.1.2.5.2.1.2.1   An interrogator shall operate using a single interrogator code.

1.1.2.5.2.1.2.2   *The use of multiple interrogator codes by one interrogator.* An interrogator shall not interleave Mode S-only all-call interrogations using different interrogator codes.

Note.— An explanation of RF interference issues, sector size and impact on data link transactions is presented in the Aeronautical Surveillance Manual (ICAO Doc 9924).

1.1.2.5.2.1.2.3   *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 (1.1.2.5.2.1.4 and 1.1.2.5.2.1.5). When two II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.

Note.— Limited data link activity including single segment Comm-A, uplink and downlink broadcast protocols and GICB extraction may be performed by both II codes.

1.1.2.5.2.1.2.4   *SI: Surveillance identifier.* This 6-bit value shall define a surveillance identifier (SI) code. These SI codes shall be assigned to interrogators in the range from 1 to 63. The SI code value of 0 shall not be used. The SI codes

shall be used with the multisite lockout protocols (1.1.2.6.9.1). The SI codes shall not be used with the multisite communications protocols (1.1.2.6.11.3.2, 1.1.2.7.4 or 1.1.2.7.7).

1.1.2.5.2.1.3   *CL: Code label.* This 3-bit (14-16) uplink field shall define the contents of the IC field.

> *Coding* (in binary)
>
> 000   signifies that the IC field contains the II code
> 001   signifies that the IC field contains SI codes 1 to 15
> 010   signifies that the IC field contains SI codes 16 to 31
> 011   signifies that the IC field contains SI codes 32 to 47
> 100   signifies that the IC field contains SI codes 48 to 63
>
> The other values of the CL field shall not be used.

1.1.2.5.2.1.3.1   *Surveillance identifier (SI) code capability report.* Transponders which process the SI codes (1.1.2.5.2.1.2.4) shall report this capability by setting bit 35 to 1 in the surveillance identifier capability (SIC) subfield of the MB field of the data link capability report (1.1.2.6.10.2.2).

1.1.2.5.2.1.4   *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 have not been assigned a unique IC (II or SI code) 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 using any interrogator code.

1.1.2.5.2.1.4.1   *Maximum Mode S-only all-call interrogation rate.* The maximum rate of Mode S-only all-call interrogations made by an interrogator using acquisition based on lockout override shall depend on the reply probability as follows –

> (a)   for a reply probability equal to 1.0: the smaller of 3 interrogations per 3 dB beam dwell or 30 interrogations per second;
>
> (b)   for a reply probability equal to 0.5: the smaller of 5 interrogations per 3 dB beam dwell or 60 interrogations per second; and
>
> (c)   for a reply probability equal to 0.25 or less: the smaller of 10 interrogations per 3 dB beam dwell or 125 interrogations per second.
>
> Note.   These limits have been defined in order to minimize the RF pollution generated by such a method while keeping a minimum of replies to allow acquisition of aircraft within a beam dwell.

1.1.2.5.2.1.4.2   Passive acquisition without using all-call interrogations shall be used in the place of lockout override.

Note.— The Aeronautical Surveillance Manual (Doc 9924) provides guidance on different passive acquisition methods.

1.1.2.5.2.1.4.3   *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 1.1.2.5.2.1.5
TMS	=	0

1.1.2.5.2.1.4.4   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 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.

1.1.2.5.2.1.5   Supplementary acquisition using II equals 0

Note 1.— The acquisition technique defined in 1.1.2.5.2.1.4 provides rapid acquisition for most aircraft. Due to the probabilistic nature of the process, 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.

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 with II=0. Only the aircraft not yet acquired and not yet locked-out will reply resulting in an easier acquisition.

1.1.2.5.2.1.5.1 Lockout within a beam dwell

1.1.2.5.2.1.5.1.1 When II equals 0 lockout is used to supplement acquisition, all aircraft within the beam dwell of the aircraft being acquired shall 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.

1.1.2.5.2.1.5.2 Duration of lockout

1.1.2.5.2.1.5.2.1 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 II equals 0 for supplementary acquisition.

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

1.1.2.5.2.2 All-call reply, downlink format 11

	6	9	33	
DF	CA	AA	PI	
5	8	32	56	
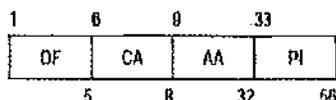
The reply to the Mode S-only all-call or the Mode A/C/S all-call interrogation shall be the Mode S all-call reply, downlink format 11. The format of this reply shall consist of these fields:

Field

DF downlink format
CA capability
AA address announced
PI parity/interrogator identifier

1.1.2.5.2.2.1 *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 on the ground

5   signifies Level 2 or above transponder and ability to set CA code 7 and airborne

6   signifies Level 2 or above transponder and ability to set CA code 7 and either airborne or on the ground

7   signifies the DR field is not equal to 0 or the FS field equals 2, 3, 4 or 5, and either airborne or on the ground

When the conditions for CA code 7 are not satisfied, 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;
(b) with automatic on-the-ground determination shall use CA code 4 when on the ground and 5 when airborne; and
Data link capability reports (1.1.2.6.10.2.2) shall be available from aircraft installations that set CA code 4, 5, 6 or 7.

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

1.1.2.5.2.2.2 *AA: Address announced.* This 24-bit (9-32) downlink field shall contain the aircraft address which provides unambiguous identification of the aircraft.

1.1.2.5.3 *Lockout protocol.* The all-call lockout protocol defined in 1.1.2.6.9 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:

(a)   the interrogator is using an IC code different from zero; and

(b)   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 determined in 1.1.2.6, 1.1.2.7 and 1.1.2.8 and the all-call lockout protocol is used to inhibit replies to further all-call interrogations.

Note 2.— Regional IC allocation bodies may define rules limiting the use of selective interrogation and lockout protocol (e.g. no lockout in defined limited area, use of intermittent lockout in defined areas, and no lockout of aircraft not yet equipped with SI code capability).

1.1.2.5.4 *Stochastic all-call protocol.* The transponder shall execute a random process upon acceptance of a Mode S-only all-call with a PR code equal to 1 to 4 or 9 to 12. A decision to reply shall be made in accordance with the probability specified in the interrogation. A transponder shall not reply if a PR code equal to 5, 6, 7, 13, 14 or 15 is received (1.1.2.5.2.1.1).

Note.— The random occurrence of replies makes it possible for the interrogator to acquire closely spaced aircraft, replies from which would otherwise synchronously garble each other.

1.1.2.6   ADDRESSED SURVEILLANCE AND STANDARD-LENGTH COMMUNICATION TRANSACTIONS

Note 1.— The interrogations described in this section are addressed to specific aircraft. There are two basic interrogation and reply types, short and long. The short interrogations and replies are UF 4 and 5 and DF 4 and 5, while the long interrogations and replies are UF 20 and 21 and DF 20 and 21.

Note 2.— The communications protocols are given in 1.1.2.6.11. These protocols describe the control of the data exchange.

1.1.2.6.1SURVEILLANCE, ALTITUDE REQUEST, UPLINK FORMAT 4

1	6	9	14	17	33
UF	PC	RR	DI	SD	AP
5	8	13	16	32	56
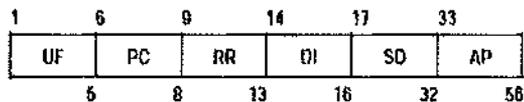
The format of this interrogation shall consist of these fields:

Field

UF uplink format
PC protocol
RR reply request
DI designator identification
SD special designator
AP address/parity

1.1.2.6.1.1   *PC: Protocol.* This 3-bit, (6-8) uplink field shall contain operating commands to the transponder. The PC field shall be ignored for the processing of surveillance or Comm-A interrogations containing DI = 3 (1.1.2.6.1.4.1).

Coding

0	signifies no action
1	signifies non-selective all-call lockout
2	not assigned
3	not assigned
4	signifies close out Comm-B
5	signifies close out uplink
6	signifies close out downlink
7	not assigned

1.1.2.6.1.2   *RR: Reply request.* This 5-bit, (9-13) uplink field shall command the length and content of a requested reply. The last four bits of the 5-bit RR code, transformed into their decimal equivalent, shall designate the BDS1 code of the requested Comm-B message if the most significant bit (MSB) of the RR code is 1 (RR is equal to or greater than 16).
Coding

RR = 0-15 shall be used to request a reply with surveillance format (DF – 4 or 5);

RR = 16-31 shall be used to request a reply with Comm-B format (DF = 20 or 21);

RR = 16 shall be used to request transmission of an air-initiated Comm-B message according to 1.1.2.6.11.3 or to request the extraction of a Comm-B broadcast message according to 1.1.2.6.11.4;

RR = 17 shall be used to request a data link capability report according to 1.1.2.6.10.2.2;

RR = 18 shall be used to request aircraft identification according to 1.1.2.9;

19 - 31 are not assigned in Part III of these Regulations.

Note.— Codes 19-31 are reserved for applications such as data link communications, Airborne Collision Avoidance Systems (Airborne Collision Avoidance System), etc.

1.1.2.6.1.3 *DI: Designator identification.* This 3-bit (14-16) uplink field shall identify the structure of the SD field (1.1.2.6.1.4).

Coding

0	signifies SD not assigned except for IIS
1	signifies SD contains multisite and communications control information
2	signifies SD contains control data for extended squitter
3	signifies SD contains SI multisite lockout, broadcast and GICB control information
4-6	signifies SD not assigned
7	signifies SD contains extended data readout request, multisite and

communications control information.

1.1.2.6.1.4 *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

```
        17      23   24   28
    ┌───────┬─────┬─────┬──────────────────┐
 3  │  SIS  │ LSS │ RRS │                  │
    └───────┴─────┴─────┴──────────────────┘
        22             27                 32


        17   21   25   26   27   29
    ┌─────┬──────┬────┬────┬───┬──────┐
 7  │ IIS │ RRS  │    │LOS │   │ TMS  │
    └─────┴──────┴────┴────┴───┴──────┘
        20    24              28    32
```
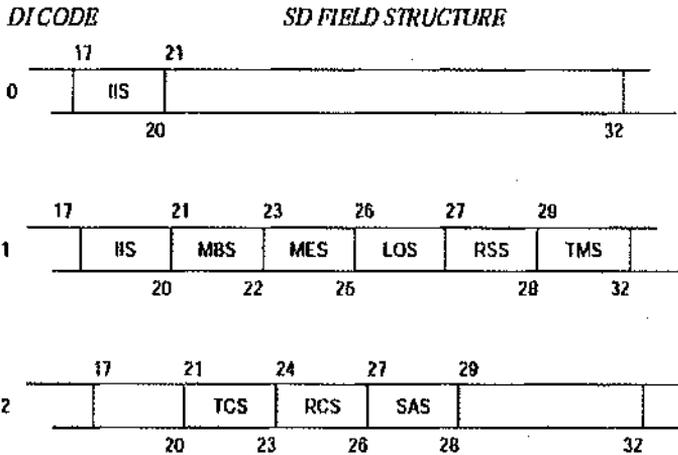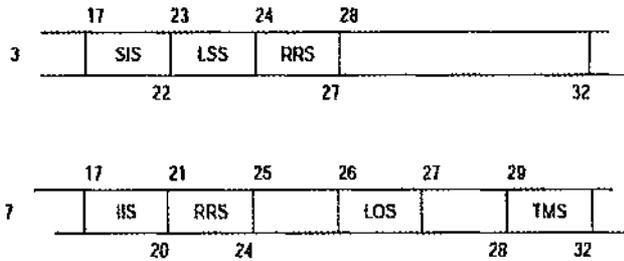
1.1.2.6.1.4.1   *Subfields in SD.* The SD field shall contain information as follows —

(a) If DI = 0, 1 or 7:
IIS, the 4-bit (17-20) interrogator identifier subfield shall contain an assigned identifier code of the interrogator (1.1.2.5.2.1.2.3);

(b) If DI = 0:
bits 21-32 are not assigned;

(c) If DI = 1:
MBS, the 2-bit (21, 22) multisite Comm-B subfield shall have the following codes:

0   signifies no Comm-B action
1   signifies air-initiated Comm-B reservation request (1.1.2.6.11.3.1)
2   signifies Comm-B closeout (1.1.2.6.11.3.2.3)
3   not assigned.

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

0   signifies no ELM action
1   signifies uplink ELM reservation request (1.1.2.7.4.1)
2   signifies uplink ELM closeout (1.1.2.7.4.2.8)
3   signifies downlink ELM reservation request (1.1.2.7.7.1.1)
4   signifies downlink ELM closeout (1.1.2.7.7.3)
5   signifies uplink ELM reservation request and downlink ELM closeout
6   signifies uplink ELM closeout and downlink ELM reservation request
7   signifies uplink ELM and downlink ELM closeouts.

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

0   signifies no request

1   signifies report Comm-B reservation status in UM
2   signifies report uplink ELM reservation status in UM
3   signifies report downlink ELM reservation status in UM;

(d) If DI = 1 or 7:

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

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

(e) If DI = 7:

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

Bits 25, 27 and 28 are not assigned;

(f) If DI = 2:

TCS, the 3-bit (21-23) type control subfield in SD shall control the on-the-ground status reported by the transponder.

The following codes have been assigned;

0   signifies no on-the-ground status command
1   signifies set and report the on-the-ground status for the next 15 seconds
2   signifies set and report the on-the-ground status for the next 60 seconds
3   signifies cancel the on-the-ground command 4-7 not assigned.

The transponder shall be able to accept a new command to set or cancel the on-the-ground status even though a prior command has not yet timed out.

Note.— Cancellation of the on-the-ground status command signifies that the determination of the vertical status reverts to the aircraft technique for this purpose. It does not signify a command to change to the vertical status.

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

0   signifies no surface position extended squitter rate command
1   signifies report high surface position extended squitter rate for 60 seconds

2	signifies report low surface position extended squitter rate for 60 seconds
3	signifies suppress all surface position extended squitters for 60 seconds
4	signifies suppress all surface position extended squitters for 120 seconds
5-7	not assigned.

Note 1.— The definition of high and low squitter rates is given in 1.1.2.8.6.4.3.

Note 2.— As stated in 1.1.2.8.5.2 d), acquisition squitters are transmitted when surface position extended squitters are suppressed by using RCS=3 or 4.

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 format, and (2) the acquisition squitter when the transponder is reporting the on-the-ground status. This subfield shall have no effect on the transponder diversity antenna selection when it is reporting the airborne 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 (1.1.2.8.6.5).

(g) If DI = 3:

SIS, the 6-bit (17-22) surveillance identifier subfield in SD shall contain an assigned surveillance identifier code of the interrogator (1.1.2.5.2.1.2.4).

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.

RRS, the 4-bit (24-27) reply request subfield in SD shall contain the BDS2 code of a requested GICB register. Bits 28 to 32 are not assigned.
h) If DI=4, 5 or 6 then the SD field has no meaning and shall not impact other transaction cycle protocols. These DI codes remain reserved until future assignment of the SD field.
i) If DI = 0, 3 or 7:

In addition to the requirements provided above, the "SD" shall contain the following:
"OVC": The 1-bit (bit 28) "overlay control" subfield in "SD" is used by the interrogator to command that the data parity ("DP" 1.3.2.1.5) be overlaid upon the resulting reply to the interrogation in accordance with paragraph 1.1.2.6.11.2.5.

1.1.2.6.1.4.2   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 (1.1.2.8.6.4.3), the identification and category message (1.1.2.8.6.4.4), the aircraft operational status message (1.1.2.8.6.4.6) and the aircraft status message (1.8.6.4.6) 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 (1.1.2.6.1.4.1 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 1.8.5 using antenna as specified in 1.1.2.8.5.3 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.

1.1.2.6.1.4.3   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 (1.1.2.8.6.4.3), the identification and category message (1.8.6.4.4), the aircraft operational status message (1.8.6.4.6) and the aircraft status message (1.8.6.4.6) 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 (1.1.2.6.1.4.1 (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 1.8.5 using antenna as specified in 1.1.2.8.5.3 (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.

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

1.1.2.6.2 COMM-A ALTITUDE REQUEST, UPLINK FORMAT 20
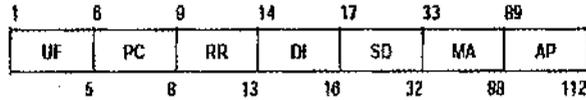
1	6	9	14	17	33	89
UF	PC	RR	DI	SD	MA	AP
5	8	13	16	32	88	112

The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format	1.1.2.3.2.1.1
PC protocol	1.1.2.6.1.1
RR reply request	1.1.2.6.1.2
DI designator identification	1.1.2.6.1.3
SD special designator	1.1.2.6.1.4
MA message, Comm-A	1.1.2.6.2.1
AP address/parity	1.1.2.3.2.1.3

1.1.2.6.2.1 *MA: Message, Comm-A.* This 56-bit (33-88) field shall contain a data link message to the aircraft.

1.1.2.6.3 SURVEILLANCE IDENTITY REQUEST, UPLINK FORMAT 5
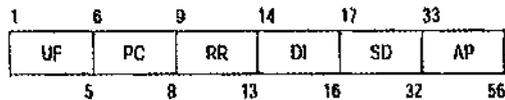
1	6	9	14	17	33
UF	PC	RR	DI	SD	AP
5	8	13	16	32	56

The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format	1.1.2.3.2.1.1
PC protocol	1.1.2.6.1.1
RR reply request	1.1.2.6.1.2
DI designator identification	1.1.2.6.1.3
SD special designator	1.1.2.6.1.4
AP address/parity	1.1.2.3.2.1.3

1.1.2.6.4 COMM-A IDENTITY REQUEST, UPLINK FORMAT 21
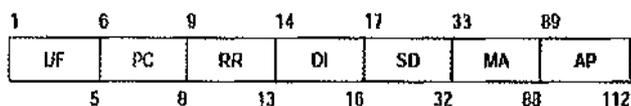
1	6	9	14	17	33	89	
UF	PC	RR	DI	SD	MA	AP	
5	8	13	16	32	88	112	

The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format	1.1.2.3.2.1.1
PC protocol	1.1.2.6.1.1
RR reply request	1.1.2.6.1.2
DI designator identification	1.1.2.6.1.3
SD special designator	1.1.2.6.1.4
MA message, Comm-A	1.1.2.6.2.1
AP address/parity	1.1.2.3.2.1.3

1.1.2.6.5 SURVEILLANCE ALTITUDE REPLY, DOWNLINK FORMAT 4
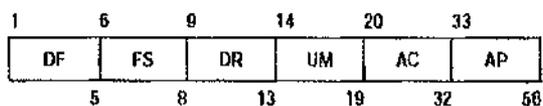
1	6	9	14	20	33	
DF	FS	DR	UM	AC	AP	
5	8	13	19	32	56	

This reply shall be generated in response to an interrogation UF 4 or 20 with an RR field value less than 16. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
FS flight status	1.1.2.6.5.1
DR downlink request	1.1.2.6.5.2
UM utility message	1.1.2.6.5.3
AC altitude code	1.1.2.6.5.4
Address/parity	1.1.2.3.2.1.3

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

Coding

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

Note.— The conditions which cause an alert are given in 1.1.2.6.10.1.1.

1.1.2.6.5.2   *DR: Downlink request.* This 5-bit (9-13) downlink field shall contain requests to downlink information.

Coding

0   signifies no downlink request
1   signifies request to send Comm-B message
2   reserved for ACAS
3   reserved for ACAS
4   signifies Comm-B broadcast message 1 available
5   signifies Comm-B broadcast message 2 available
6   reserved for ACAS
7   reserved for ACAS
8-15   not assigned
16-31   see downlink ELM protocol (1.1.2.7.7.1)

Codes 1-15 shall take precedence over codes 16-31.

Note.— Giving precedence to codes 1-15 permits the announcement of a Comm-B message to interrupt the announcement of a downlink ELM. This gives priority to the announcement of the shorter message.

1.1.2.6.5.3   *UM: Utility message.* This 6-bit (14-19) downlink field shall contain transponder communications status information as specified in 1.1.2.6.1.4.1 and 1.1.2.6.5.3.1.

1.1.2.6.5.3.1   Subfields in UM for multisite protocols

        UM FIELD STRUCTURE

```
      14        18
     ┌──┬─────┬──────┐
     │IIS│ IDS │      │
     └──┴─────┴──────┘
         17     19
```
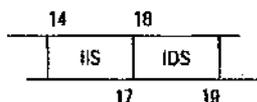
The following subfields shall be inserted by the transponder into the UM field of the reply if a surveillance or Comm-A interrogation (UF equals 4, 5, 20, 21) contains DI = 1 and RSS other than 0:

IIS: The 4-bit (14-17) interrogator identifier subfield reports the identifier of the interrogator that is reserved for multisite communications.

IDS: The 2-bit (18, 19) identifier designator subfield reports the type of reservation made by the interrogator identified in IIS.

    Assigned coding is:

    0   signifies no information
    1   signifies IIS contains Comm-B II code
    2   signifies IIS contains Comm-C II code
    3   signifies IIS contains Comm-D II code.

1.1.2.6.5.3.2   *Multisite reservation status.* The interrogator identifier of the ground station currently reserved for multisite Comm-B delivery (1.1.2.6.11.3.1) shall be transmitted in the IIS subfield together with code 1 in the IDS subfield if the UM content is not specified by the interrogation (when DI = 0 or 7, or when DI = 1 and RSS = 0).

The interrogator identifier of the ground station currently reserved for downlink ELM delivery (1.1.2.7.6.1), if any, shall be transmitted in the IIS subfield together with code 3 in the IDS subfield if the UM content is not specified by the interrogation and there is no current Comm-B reservation.

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

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

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

    (c) If the M bit (bit 26) and the Q bit (bit 28) equal 0, the altitude shall be coded according to the pattern for Mode C replies of 1.1.2.12.2.3. Starting with bit 20 the sequence shall be C1, A1, C2, A2, C4, A4, ZERO, B1, ZERO, B2, D2, B4, D4;

(d) If the M bit equals 0 and the Q bit equals 1, the 11-bit field represented by bits 20 to 25, 27 and 29 to 32 shall represent a binary coded field with a least significant bit (LSB) of 25 ft. The binary value of the positive decimal integer "N" shall be encoded to report pressure-altitude in the range [(25 N − 1 000) plus or minus 12.5 ft]. The coding of 1.1.2.6.5.4 *(c)*shall be used to report pressure-altitude above 50 187.5 ft.

Note 1.— This coding method is only able to provide values between minus 1 000 ft and plus 50 175 ft.

Note 2.— The most significant bit (MSB) of this field is bit 20 as required by 1.1.2.3.1.3.

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

(f) 0 shall be transmitted in each of the 13 bits of the AC field if altitude information is not available or if the altitude has been determined invalid.

1.1.2.6.6 COMM-B ALTITUDE REPLY, DOWNLINK FORMAT 20
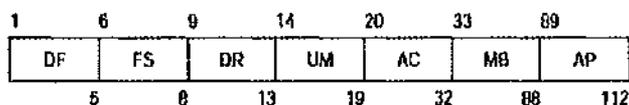
1	6	9	14	20	33	89	
DF	FS	DR	UM	AC	MB	AP	
5	8	13	19	32	88	112	

This reply shall be generated in response to an interrogation UF 4 or 20 with an RR field value greater than 15. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
FS flight status	1.1.2.6.5.1
DR downlink request	1.1.2.6.5.2
UM utility message	1.1.2.6.5.3
AC altitude code	1.1.2.6.5.4
MB message, Comm-B	1.1.2.6.6.1
Address/parity	1.1.2.3.2.1.3

1.1.2.6.6.1 *MB: Message, Comm-B.* This 56-bit (33-88) downlink field shall be used to transmit data link messages to the ground.

1.1.2.6.7 SURVEILLANCE IDENTITY REPLY, DOWNLINK FORMAT 5
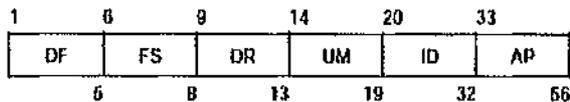
1	6	9	14	20	33	
DF	FS	DR	UM	ID	AP	
	5	8	13	19	32	56

This reply shall be generated in response to an interrogation UF 5 or 21 with an RR field value less than 16. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
FS flight status	1.1.2.6.5.1
DR downlink request	1.1.2.6.5.2
UM utility message	1.1.2.6.5.3
ID identity	1.1.2.6.7.1
Address/parity	1.1.2.3.2.1.3

1.1.2.6.7.1   *ID: Identity (Mode A code)*. This 13-bit (20-32) field shall contain aircraft identity code, in accordance with the pattern for Mode A replies in 1.1.1.6 Starting with bit 20, the sequence shall be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4.

1.1.2.6.8   COMM-B IDENTITY REPLY, DOWNLINK FORMAT 21
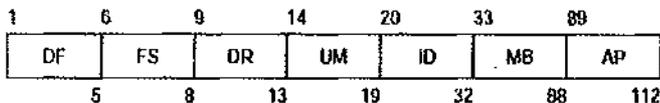
1	6	9	14	20	33	89	
DF	FS	DR	UM	ID	MB	AP	
	5	8	13	19	32	88	112

This reply shall be generated in response to an interrogation UF 5 or 21 with an RR field value greater than 15. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
FS flight status	1.1.2.6.5.1
DR downlink request	1.1.2.6.5.2
UM utility message	1.1.2.6.5.3
ID Identity	1.1.2.6.7.1
MB message, Comm-B	1.1.2.6.6.1
Address/parity	1.1.2.3.2.1.3

1.1.2.6.9   LOCKOUT PROTOCOLS

Note - Non-selective all-call lockout and multisite lockout are not mutually exclusive. Interrogators using multisite lockout protocols for interrogator networking coordination may use non-selective lockout commands in the same interrogation. For example, the non-selective lockout may be used to prevent Mode S transponder replies with DF=11 to wrongly detected Mode A/C/S all-call interrogations from Mode A/C-only all-call interrogations. This is because of the misinterpretation of the narrow P4 pulse as a wide P4 pulse.

1.1.2.6.9.1   Multisite all-call lockout

Note.— The multisite lockout protocol prevents transponder acquisition from being denied one ground station by lockout commands from an adjacent ground station that has overlapping coverage.

1.1.2.6.9.1.1   The multisite lockout command shall be transmitted in the SD field (1.1.2.6.1.4.1). 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 (that is, 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 TL (1.1.2.10.3.9) 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 (1.1.1.6.9.2).

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.

1.1.2.6.9.2   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 (that is, 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 1.1.2.1.5.1.1.

This lockout condition shall persist for an interval TD (1.10.3.9) 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 2.— Non-selective lockout does not affect the response of the transponder to Mode S-only all-call interrogations containing II not equal to 0.

1.1.2.6.10   BASIC DATA PROTOCOLS

1.1.2.6.10.1   *Flight status protocol.* Flight status shall be reported in the FS field.

1.1.2.6.10.1.1   *Alert.* An alert condition shall be reported in the FS field if the Mode A identity code transmitted in Mode A replies and in downlink formats DF equals 5 and DF equals 21 are changed by the pilot.

1.1.2.6.10.1.1.1   *Permanent alert condition.* The alert condition shall be maintained if the Mode-A identity code is changed to 7500, 7600 or 7700.

1.1.2.6.10.1.1.2   *Temporary alert condition.* The alert condition shall be temporary and shall cancel itself after *TC* seconds if the Mode A identity code is changed to a value other than those listed in 1.1.2.6.10.1.1.1. The *TC* shall be retriggered and continued for *TC* seconds after any change has been accepted by the transponder function.

Note 1.   This retriggering is performed to ensure that the ground interrogator obtains the desired Mode A identity code before the alert condition is cleared.

Note 2.— The value of TC is given in 1.1.2.10.3.9.

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

1.1.2.6.10.1.2   *Ground report.* The on-the-ground status of the aircraft shall be reported in the CA field (1.1.2.5.2.2.1), the FS field (1.1.2.6.5.1), and the VS field (1.1.2.8.2.1). 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 1.1.2.6.10.3.1. If such indication is not available at the transponder data interface (1.1.2.10.5.1.3), 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)

1.1.2.6.10.1.3   *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 *TI* seconds after initiation (1.1.1.6, 1.1.1.7 and 1.1.2.8.6.3.1.1).

Note.— The value of TI is given in 1.1.2.10.3.9.

1.1.2.6.10.2   *Capability reporting protocol.* The data structure and content of the data link capability report registers shall be implemented in such a way that interoperability is ensured.

Note 1.— Aircraft capability is reported in special fields as defined in the following paragraphs.

Note 2.— The data format of the registers for reporting capability is specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.6.10.2.1   *Capability report.* The 3-bit CA field, contained in the all-call reply, DF equals 11, shall report the basic capability of the Mode S transponder as described in 1.1.2.5.2.2.1.

1.1.2.6.10.2.2   *Data link capability report.* The data link capability report shall provide the interrogator with a description of the data link capability of the Mode S installation.

Note.— The data link capability report is contained in register 10₁₆ with a possible extension in registers 11₁₆ to 16₁₆ when any continuation will be required.

1.1.2.6.10.2.2.1   *Extraction and subfields in MB for data link capability report*

1.1.2.6.10.2.2.1.1   *Extraction of the data link capability report contained in register 10₁₆.* The report shall be obtained by a ground-initiated Comm-B reply in response to an interrogation containing RR equals 17 and DI is not equal to 7 or DI equals 7 and RRS equals 0 (1.1.2.6.11.2).

1.1.2.6.10.2.2.1.2   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.

1.1.2.6.10.2.2.1.3   The data link capability report shall contain information on the following capabilities as specified in Table 1-6 in Schedule 1.

1.1.2.6.10.2.2.1.4   The Mode S subnetwork version number shall contain information to ensure interoperability with older airborne equipment.

1.1.2.6.10.2.2.1.4.1   The Mode S subnetwork version number shall indicate that all implemented subnetwork functions are in compliance with the requirements of the indicated version number. The Mode S subnetwork version number shall be set to a non-zero value if at least one DTE or Mode S specific service is installed.

Note.— The version number does not indicate that all possible functions of that version are implemented.

1.1.2.6.10.2.2.2   *Updating of the data link capability report.* The transponder shall, at intervals not exceeding four seconds, compare the current data link capability status (bits 41-88 in the data link capability report) with that last reported and shall, if a difference is noted, initiate a revised data link capability report by Comm-B broadcast (1.1.2.6.11.4) for BDS1 = 1 (33-36) and BDS 2 = 0 (37-40). The transponder shall initiate, generate and announce the revised capability report even if the aircraft data link capability is degraded or lost. The transponder shall ensure that the BDS code is set for the data link capability report in all cases, including a loss of the interface.

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

1.1.2.6.10.2.2.3   *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 1016).

Note.— 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.

1.1.2.6.10.2.3 *Common usage GICB capability report.* Common usage GICB services which are being actively updated shall be indicated in transponder register 17₁6.

1.1.2.6.10.2.4 *Mode S specific services GICB capability reports.* GICB services that are installed shall be reported in registers 18₁6 to 1C16.

1.1.2.6.10.2.5 *Mode S specific services MSP capability reports.* MSP services that are installed shall be reported in registers 1D16 to 1F16.

1.1.2.6.10.3 Validation of on-the-ground status declared by an automatic means

Note.— For aircraft with an automatic means of determining vertical status, the CA field reports whether the aircraft is airborne or on the ground. ACAS II acquires aircraft using the short or extended squitter, both of which contain the CA field. If an aircraft reports on-the-ground status, that aircraft will not be interrogated by ACAS II in order to reduce unnecessary interrogation activity. If the aircraft is equipped to report extended squitter messages, the function that formats these messages may have information available to validate that an aircraft reporting "on-the-ground" is actually airborne.

1.1.2.6.10.4 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 or if the on-the-ground status has been commanded via the TCS subfield (1.1.2.6.1.4.1 f)), 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

1.1.2.6.11 STANDARD LENGTH COMMUNICATIONS PROTOCOLS

Note 1.— The two types of standard length communications protocols are Comm-A and Comm-B; messages using these protocols are transferred under the control of the interrogator. Comm-A messages are sent directly to the transponder and are completed within one transaction. A Comm-B message is used to transfer information from air to ground and can be initiated either by the interrogator or the transponder. In the case of ground-initiated Comm-B transfers, the interrogator requests data to be read out from the transponder, which delivers the message in the same transaction. In the case of air-initiated Comm-B transfers, the

transponder announces the intention to transmit a message; in a subsequent transaction an interrogator will extract the message.

Note 2.— In a non-selective air-initiated Comm-B protocol all transactions necessary can be controlled by any interrogator.

Note 3.— In some areas of overlapping interrogator coverage there may be no means for coordinating interrogator activities via ground communications. Air-initiated Comm-B communications protocols require more than one transaction for completion. Provision is made to ensure that a Comm-B message is closed out only by the interrogator that actually transferred the message. This can be accomplished through the use of the multisite Comm-B communications protocols or through the use of the enhanced Comm-B communications protocols.

Note 4.— The multisite and the non-selective communications protocols cannot be used simultaneously in a region of overlapping interrogator coverage unless the interrogators coordinate their communications activities via ground communications.

Note 5.— The multisite communications protocol is independent of the multisite lockout protocol. That is, the multisite communications protocol may be used with the non-selective lockout protocol and vice versa. The choice of lockout and communications protocols to be used depends upon the network management technique being used.

Note 6.— The broadcast Comm-B protocol can be used to make a message available to all active interrogators.

1.1.2.6.11.1   *Comm-A.* The interrogator shall deliver a Comm-A message in the MA field of an interrogation UF = 20 or 21.

1.1.2.6.11.1.1   *Comm-A technical acknowledgement.* Acceptance of a Comm-A interrogation shall be automatically technically acknowledged by the transponder, by the transmission of the requested reply (1.1.2.6.10.5.2.2.1).

Note.— The receipt of a reply from the transponder according to the rules of 1.1.2.4.1.2.3 d) and 1.1.2.4.1.3.2.2.2 is the acknowledgement to the interrogator that the interrogation has been accepted by the transponder. If either uplink or downlink fail, this reply will be missing and the interrogator will normally send the message again. In the case of downlink failure, the transponder may receive the message more than once.

1.1.2.6.11.1.2   *Comm-A broadcast.* If a Comm-A broadcast interrogation is accepted (1.1.2.4.1.2.3.1.3) information transfer shall be handled according to

1.1.2.10.5.2.1.1 but other transponder functions shall not be affected and a reply shall not be transmitted.

Note 1.— There is no technical acknowledgement to a Comm-A broadcast message.

Note 2.— Since the transponder does not process the control fields of a Comm-A broadcast interrogation, the 27 bits following the UF field are also available for user data.

1.1.2.6.11.2   *Ground-initiated Comm-B*

1.1.2.6.11.2.1   *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 Civil Aviation (Communication Systems), Regulations 2020, Schedule 2, Table 5-24

1.1.2.6.11.2.2   *BDS1 code.* The BDS1 code shall be as defined in the RR field of a surveillance or Comm-A interrogation.

1.1.2.6.11.2.3   *BDS2 code.* The BDS2 code shall be as defined in the RRS subfield of the SD field (1.1.2.6.1.4.1) when DI = 7. If no BDS2 code is specified (that is, DI is not equal to 7) it shall signify that BDS2 = 0.

1.1.2.6.11.2.4   *Protocol.* On receipt of such a request, the MB field of the reply shall contain the contents of the requested ground-initiated Comm-B register.

1.1.2.6.11.2.4.1   If the requested register is not serviced by the aircraft installation, the transponder shall reply and the MB field of the reply shall contain all ZEROs.

1.1.2.6.11.2.5   Overlay control. If the "DI" code of the Comm-B requesting interrogation is 0, 3 or 7, the "SD" contains the overlay control (OVC) field in accordance with paragraph 1.1.2.6.1.4.1 (i)).

    (a) If the "OVC" is equal to "1," then the reply to the interrogation shall contain the "DP" (data parity) field in accordance with paragraph 1.1.2.3.2.1.5; and

    (b) If the "OVC" is equal to "0," then the reply to the interrogation shall contain the "AP" field in accordance with paragraph 1.1.2.3.2.1.3.

1.1.2.6.11.3   *Air-initiated Comm-B*

1.1.2.6.11.3.1 *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 (1.1.2.6.11.3.2.1 and 1.1.2.6.11.3.3.1). 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.

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.

1.1.2.6.11.3.2 Additional protocol for multisite air-initiated Comm-B

Note.— The announcement of an air-initiated Comm-B message waiting to be delivered may be accompanied by a multisite reservation status report in the UM field (1.1.2.6.5.3.2).

An interrogator shall not attempt to extract a message if it has determined that it is not the reserved site.

1.1.2.6.11.3.2.1 *Message transfer.* An interrogator shall request a Comm-B reservation and extract an air-initiated Comm-B message by transmitting a surveillance or Comm-A interrogation UF equals 4, 5, 20 or 21 containing:

RR = 16
DI = 1
IIS = assigned interrogator identifier
MBS = 1 (Comm-B reservation request)

Note.— A Comm-B multisite reservation request is normally accompanied by a Comm-B reservation status request (RSS = 1). This causes the interrogator identifier of the reserved site to be inserted in the UM field of the reply.

1.1.2.6.11.3.2.1.1   Protocol procedure in response to this interrogation shall depend upon the state of the B-timer which indicates if a Comm-B reservation is active. This timer shall run for *TR* seconds.

Note 1.— The value of TR is given in 1.1.2.10.3.9.

(a) If the B-timer is not running, the transponder shall grant a reservation to the requesting interrogator by –

(i) storing the IIS of the interrogation as the Comm-B II, and

(ii) starting the B-timer.

A multisite Comm-B reservation shall not be granted by the transponder unless an air-initiated Comm-B message is waiting to be transmitted and the requesting interrogation contains RR equals 16, DI equals 1, MBS equals 1 and IIS is not 0.

(b) If the B-timer is running and the IIS of the interrogation equals the Comm-B II, the transponder shall restart the B-timer.

(c) If the B-timer is running and the IIS of the interrogation does not equal the Comm-B II, then there shall be no change to the Comm-B II or the B-timer.

Note 2.— In case *(c)* the reservation request has been denied.

1.1.2.6.11.3.2.1.2   In each case the transponder shall reply with the Comm-B message in the MB field.

1.1.2.6.11.3.2.1.3   An interrogator shall determine if it is the reserved site for this message through coding in the UM field. If it is the reserved site it shall attempt to close out the message in a subsequent interrogation. If it is not the reserved site it shall not attempt to close out the message.

1.1.2.6.11.3.2.2   *Multisite-directed Comm-B transmissions.* To direct an air-initiated Comm-B message to a specific interrogator, the multisite Comm-B protocol shall be used. When the B-timer is not running, the interrogator identifier of the desired destination shall be stored as the Comm-B II. Simultaneously the B-timer shall be started and the DR code shall be set to 1. For a multisite-directed Comm-B message, the B-timer shall not automatically time out but shall continue to run until –

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

(b) the message is cancelled (1.10.5.4) by the data link avionics.

Note.— The protocols of 1.6.5.3 and 1.6.11.3.2.1 will then result in delivery of the message to the reserved site. The data link avionics may cancel the message if delivery to the reserved site cannot be accomplished.

1.1.2.6.11.3.2.3　*Multisite Comm-B closeout.* The interrogator shall close out a multisite air-initiated Comm-B by transmitting either a surveillance or a Comm-A interrogation containing:

either DI = 1

IIS　　=　　assigned interrogator identifier
MBS　=　　2 (Comm-B closeout)

or DI　=　　0, 1 or 7

IIS　　=　　assigned interrogator identifier
PC　　=　　4 (Comm-B closeout)

The transponder shall compare the IIS of the interrogation to the Comm-B II and if the interrogator identifiers do not match, the message shall not be cleared and the status of the Comm-B II, B-timer, and DR code shall not be changed. If the interrogator identifiers match, the transponder shall set the Comm-B II to 0, reset the B-timer, clear the DR code for this message and clear the message itself. The transponder shall not close out a multisite air-initiated Comm-B message unless it has been read out at least once by the reserved site.

1.1.2.6.11.3.2.4　*Automatic expiration of Comm-B reservation.* If the B-timer period expires before a multisite closeout has been accomplished, the Comm-B II shall be set to 0 and the B-timer reset. The Comm-B message and the DR field shall not be cleared by the transponder.

Note.— This makes it possible for another site to read and clear this message.

1.1.2.6.11.3.3 Additional protocol for non-selective air-initiated Comm-B

Note.— In cases where the multisite protocols are not required (that is, no overlapping coverage or sensor coordination via ground-to-ground communication), the non-selective air-initiated Comm-B protocol may be used.

1.1.2.6.11.3.3.1   *Message transfer.* The interrogator shall extract the message by transmitting either RR equals 16 and DI is not equal to 7, or RR equals 16, DI equals 7 and RRS equals 0 in a surveillance or Comm-A interrogation.

1.1.2.6.11.3.3.2   *Comm-B closeout.* The interrogator shall close out a non-selective air-initiated Comm-B message by transmitting PC equals 4 (Comm-B closeout). On receipt of this command, the transponder shall perform closeout, unless the B-timer is running. If the B-timer is running, indicating that a multisite reservation is in effect, closeout shall be accomplished as per 1.1.2.6.11.3.2.3. The transponder shall not close out a non-selective air-initiated Comm-B message unless it has been read out at least once by an interrogation using non-selective protocols.

1.1.2.6.11.3.4 *Enhanced air-initiated Comm-B protocol*

Note.— The enhanced air-initiated Comm-B protocol provides a higher data link capacity by permitting parallel delivery of air-initiated Comm-B messages by up to sixteen interrogators, one for each II code. Operation without the need for multisite Comm-B reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced air-initiated Comm-B protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.

1.1.2.6.11.3.4.1   The transponder shall be capable of storing each of the sixteen II codes:

(a)   an air-initiated or multisite-directed Comm-B message; and

(b)   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

1.1.2.6.11.3.4.2   *Enhanced multisite air-initiated Comm-B protocol*

1.1.2.6.11.3.4.2.1   *Initiation.* An air-initiated Comm-B message input into the transponder shall be stored in the registers assigned to $II = 0$.

1.1.2.6.11.3.4.2.2   *Announcement and extraction.* A waiting air-initiated Comm-B message shall be announced in the DR field of the replies to all interrogators for which a multisite directed Comm-B message is not waiting. The UM field of the announcement reply shall indicate that the message is not reserved for any II code, that is, the IIS subfield shall be set to 0. When a command to read this message is received from a given interrogator, the reply containing the message shall contain an IIS subfield content indicating that

the message is reserved for the II code contained in the interrogation from that interrogator. After readout and until closeout, the message shall continue to be assigned to that II code. Once a message is assigned to a specific II code, announcement of this message shall be no longer made in the replies to interrogators with other II codes. If the message is not closed out by the assigned interrogator for the period of the B-timer, the message shall revert to multisite air-initiated status and the process shall repeat. Only one multisite air-initiated Comm-B message shall be in process at a time.

1.1.2.6.11.3.4.2.3 *Closeout.* A closeout for a multisite air-initiated message shall only be accepted from the interrogator that is currently assigned to transfer the message.

1.1.2.6.11.3.4.2.4 *Announcement of the next message waiting.* The DR field shall indicate a message waiting in the reply to an interrogation containing a Comm-B closeout if an unassigned air-initiated message is waiting and has not been assigned to a II code, or if a multisite-directed message is waiting for that II code (1.1.2.6.11.3.4.3).

1.1.2.6.11.3.4.3 *Enhanced multisite directed Comm-B protocol*

1.1.2.6.11.3.4.3.1 *Initiation.* When a multisite directed message is input into the transponder, it shall be placed in the Comm-B registers assigned to the II code specified for the message. If the registers for this II code are already occupied, (that is, a multisite directed message is already in process to this II code) the new message shall be queued until the current transaction with that II code is closed out.

1.1.2.6.11.3.4.3.2 *Announcement.* Announcement of a Comm-B message waiting transfer shall be made using the DR field as specified in 1.1.2.6.5.2 with the destination interrogator II code contained in the IIS subfield as specified in 1.1.2.6.5.3.2. The DR field and IIS subfield contents shall be set specifically for the interrogator that is to receive the reply. A waiting multisite directed message shall only be announced in the replies to the intended interrogator. It shall not be announced in the replies to other interrogators.

Note 1.— If a multisite-directed message is waiting for II = 2, the surveillance replies to that interrogator will contain DR = 1 and IIS = 2. If this is the only message in process, replies to all other interrogators will indicate that no message is waiting.

Note 2.— In addition to permitting parallel operation, this form of announcement enables a greater degree of announcement of downlink

ELMs. The announcements for the downlink ELM and the Comm-B share the DR field. Only one announcement can take place at a time due to coding limitations. In case both a Comm-B and a downlink ELM are waiting, announcement preference is given to the Comm-B. In the example above, if an air-directed Comm-B was waiting for II = 2 and a multisite-directed downlink ELM was waiting for II = 6, both interrogators would see their respective announcements on the first scan since there would be no Comm-B announcement to II = 6 to block the announcement of the waiting downlink ELM.

1.1.2.6.11.3.4.3.3   *Closeout.* Closeout shall be accomplished as specified in 1.1.2.6.11.3.2.3.

1.1.2.6.11.3.4.3.4   *Announcement of the next message waiting.* The DR field shall indicate a message waiting in the reply to an interrogation containing a Comm-B closeout if another multisite directed message is waiting for that II code, or if an air-initiated message is waiting and has not been assigned to a II code.

1.1.2.6.11.3.4.4   *Enhanced non-selective Comm-B protocol.* The availability of a non-selective Comm-B message shall be announced to all interrogators. Otherwise, the protocol shall be as specified in 1.1.2.6.11.3.3.

1.1.2.6.11.4   *Comm-B broadcast*

Note 1.— A Comm-B message may be broadcast to all active interrogators within range. Messages are alternately numbered 1 and 2 and are self-cancelling after 18 seconds. Interrogators have no means to cancel Comm-B broadcast messages.

Note 2.— Use of the Comm-B broadcast is restricted to transmission of information which does not require a subsequent ground-initiated uplink response.

Note 3.— The timer used for the Comm-B broadcast cycle is the same as that used for the Comm-B multisite protocol.

Note 4.— Data formats for Comm-B broadcast are specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.6.11.4.1   *Initiation.*

1.1.2.6.11.4.1.1   A Comm-B broadcast cycle shall begin with the –

(a) loading of the broadcast message into the Comm-B buffer;

(b) starting of the B-timer for the current Comm-B message; and

Note.— If there is more than one Comm-B message waiting for transmission, the timer is only started once the message becomes the current Comm-B broadcast.

>   *(c)*   the selection of DR code 4 or 5, (1.1.2.6.5.2) for insertion into future replies with DF 4, 5, 20 or 21 when ACAS information is not available, or DR code 6 or 7 when ACAS information is available.

1.4.1.2   The DR field shall be changed to the next value each time a new Comm-B broadcast message is initiated by the transponder.

Note.— The change of the DR value is used by the interrogator to detect that a new Comm-B broadcast message is announced and to extract the new Comm-B message.

1.4.1.3   A Comm-B broadcast cycle shall not be initiated when an air-initiated Comm-B message is waiting to be transmitted.

1.4.1.4   A new Comm-B broadcast cycle shall not interrupt a current Comm-B broadcast cycle.

1.4.2   *Extraction.* 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

1.4.3   *Expiration.* When the B-timer period expires, the transponder shall clear the DR code for this message, discard the present broadcast message and change the broadcast message number (from 1 to 2 or 2 to 1) in preparation for a subsequent Comm-B broadcast.

1.4.4   *Interruption.* In order to prevent a Comm-B broadcast cycle from delaying the delivery of an air-initiated Comm-B message, provision shall be made for an air-initiated Comm-B to interrupt a Comm-B broadcast cycle. If a broadcast cycle is interrupted, the B-timer shall be reset, the interrupted broadcast message shall be retained and the message number shall not be changed. Delivery of the interrupted broadcast message shall recommence when no air-initiated Comm-B transaction is in effect. The message shall then be broadcast for the full duration of the B-timer.

1.4.5   *Enhanced broadcast Comm-B protocol.* A broadcast Comm-B message shall be announced to all interrogators using II codes. The message shall remain active for the period of the B-timer for each II code. The provision for interruption of a broadcast by non-broadcast Comm-B as specified in 1.1.2.6.11.4.4 shall apply separately to each II code. When the B-timer period has been achieved for all II codes, the broadcast message shall be automatically

cleared as specified in 1.1.2.6.11.4.3. A new broadcast message shall not be initiated until the current broadcast has been cleared.

Note.— Due to the fact that broadcast message interruption occurs independently for each II code, it is possible that the broadcast message timeout will occur at different times for different II codes.

1.1.2.6.11.4.6   *Management of Comm-B messages waiting for transmission.* If the content of a waiting Comm-B broadcast message is updated, only the most recent value for each downlink broadcast identifier shall be retained and broadcast once the current Comm-B broadcast is finished.

Note.— Downlink broadcast identifiers are defined in the Manual on Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.7   EXTENDED LENGTH COMMUNICATION TRANSACTIONS

Note 1.— Long messages, either on the uplink or the downlink, can be transferred by the extended length message (ELM) protocols using Comm-C (UF = 24) and Comm-D (DF = 24) formats respectively. The ELM uplink protocol provides for the transmission on the uplink of up to sixteen 80-bit message segments before requiring a reply from the transponder. They also allow a corresponding procedure on the downlink.

Note 2.— In some areas of overlapping interrogator coverage there may be no means for coordinating interrogator activities via ground communications. However, the ELM communication protocols require more than one transaction for completion; coordination is thus necessary to ensure that segments from different messages are not interleaved and that transactions are not inadvertently closed out by the wrong interrogator. This can be accomplished using the multisite communications protocols or using the enhanced ELM protocols.

Note 3.— Downlink extended length messages are transmitted only after authorization by the interrogator. The segments to be transmitted are contained in Comm-D replies. As with air-initiated Comm-B messages, downlink ELMs are either announced to all interrogators or directed to a specific interrogator. In the former case an individual interrogator can use the multisite protocol to reserve for itself the ability to close out the downlink ELM transaction. A transponder can be instructed to identify the interrogator that has reserved the transponder for an ELM transaction. Only that interrogator can close out the ELM transaction and reservation.

Note 4.— The multisite protocol and the non-selective protocol cannot be used simultaneously in a region of overlapping interrogator coverage unless the interrogators coordinate their communications activities via ground communications.

1.1.2.7.1 COMM-C, UPLINK FORMAT 24
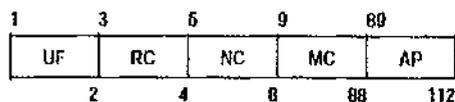
UF	RC	NC	MC	AP

Bit positions: 1, 3, 5, 9, 89 (top) and 2, 4, 8, 88, 112 (bottom)

The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format	1.1.2.3.2.1.1
RC reply control	1.1.2.7.1.1
NC number of C-segment	1.1.2.7.1.2
MC message, Comm-C	1.1.2.7.1.3
Address/parity	1.1.2.3.2.1.3

1.1.2.7.1.1 *RC: Reply control.* This 2-bit (3-4) uplink field shall designate segment significance and reply decision.

Coding

RC = 0 signifies uplink ELM initial segment in MC
= 1 signifies uplink ELM intermediate segment in MC
= 2 signifies uplink ELM final segment in MC
= 3 signifies a request for downlink ELM delivery (1.1.2.7.7.2)

1.1.2.7.1.2 *NC: Number of C-segment.* This 4-bit (5-8) uplink field shall designate the number of the message segment contained in MC (1.7.4.2.1). NC shall be coded as a binary number.

1.1.2.7.1.3 *MC: Message, Comm-C.* This 80-bit (9-88) uplink field shall contain –

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

(b) control codes for a downlink ELM, the 16-bit (9-24) SRS subfield (1.1.2.7.7.2.1) and the 4-bit (25-28) IIS subfield.

Note.— Message content and codes are not included in this chapter except for 1.1.2.7.7.2.1.

1.1.2.7.2 INTERROGATION-REPLY PROTOCOL FOR UF24

Note.— Interrogation-reply coordination for the above format follows the protocol outlined in Table 1-7 in Schedule 1 (1.1.2.4.1.3.2.2)

1.1.2.7.3 COMM-D, DOWNLINK FORMAT 24
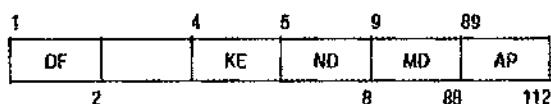
```
1           4     5    9     89
|  DF  |    | KE | ND | MD | AP  |
      2                 8   88   112
```

The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
Spare- 1 bit	
KE control ELM	1.1.2.7.3.1
ND number of D-segment	1.1.2.7.3.2
MD message, Comm-D	1.1.2.7.3.3
Address/parity	1.1.2.3.2.1.3

1.1.2.7.3.1 *KE: Control, ELM.* This 1-bit (4) downlink field shall define the content of the ND and MD fields.

Coding

KE = 0 signifies downlink ELM transmission
     1 signifies uplink ELM acknowledgement

1.1.2.7.3.2 *ND: Number of D-segment.* This 4-bit (5-8) downlink field shall designate the number of the message segment contained in MD (1.1.2.7.7.2). ND shall be coded as a binary number.

1.1.2.7.3.3 *MD: Message, Comm-D.* This 80-bit (9-88) downlink field shall contain —

(a) one of the segments of a sequence used to transmit a downlink ELM to the interrogator; or

(b) control codes for an uplink ELM.

1.1.2.7.4 MULTISITE UPLINK ELM PROTOCOL

1.1.2.7.4.1 *Multisite uplink ELM reservation.* An interrogator shall request a reservation for an uplink ELM by transmitting a surveillance or Comm-A interrogation containing:

DI   = 1
IIS   = assigned interrogator identifier
MES = 1 or 5 (uplink ELM reservation request)

Note.— A multisite uplink ELM reservation request is normally accompanied by an uplink ELM reservation status request (RSS = 2). This causes the interrogator identifier of the reserved site to be inserted in the UM field of the reply.

1.1.2.7.4.1.1 Protocol procedure in response to this interrogation shall depend upon the state of the C-timer which indicates if an uplink ELM reservation is active. This timer shall run for *TR* seconds.

Note 1.— The value of TR is given in 1.1.2.10.3.9.

(a) If the C-timer is not running, the transponder shall grant a reservation to the requesting interrogator by:

(i) storing the IIS of the interrogation as the Comm-C II and,
(ii) starting the C-timer;

(b) If the C-timer is running and the IIS of the interrogation equals the Comm-C II, the transponder shall restart the C-timer; and

(c) If the C-timer is running and the IIS of the interrogation does not equal the Comm-C II, there shall be no change to the Comm-C II or the C-timer.

Note 2.— In case *(c)* the reservation request has been denied.

1.1.2.7.4.1.2 An interrogator shall not start ELM activity unless, during the same scan, having requested an uplink ELM status report, it has received its own interrogator identifier as the reserved interrogator for uplink ELM in the UM field.

Note.— If ELM activity is not started during the same scan as the reservation, a new reservation request may be made during the next scan.

1.1.2.7.4.1.3   If uplink ELM delivery is not completed on the current scan, the interrogator shall ensure that it still has a reservation before delivering additional segments on a subsequent scan.

1.1.2.7.4.2   *Multisite uplink ELM delivery.* The minimum length of an uplink ELM shall be 2 segments, the maximum length shall be 16 segments.

1.1.2.7.4.2.1   *Initial segment transfer.* The interrogator shall begin the ELM uplink delivery for an n-segment message (NC values from 0 to n-1) by a Comm-C transmission containing RC equals 0. The message segment transmitted in the MC field shall be the last segment of the message and shall carry NC equals n-1. On receipt of an initializing segment (RC = 0) the transponder shall establish a "setup" defined as —

(a) clearing the number and content of previous segment storage registers and the associated TAS field;
(b) assigning storage space for the number of segments announced in NC of this interrogation; and
(c) storing the MC field of the segment received.

The transponder shall not reply to this interrogation. Receipt of another initializing segment shall result in a new setup within the transponder.

1.1.2.7.4.2.2   *Transmission acknowledgement.* The transponder shall use the TAS subfield to report the segments received so far in an uplink ELM sequence. The information contained in the TAS subfield shall be continually updated by the transponder as segments are received.

Note.— Segments lost in uplink transmission are noted by their absence in the TAS report and are retransmitted by the interrogator which will then send further final segments to assess the extent of message completion.

1.1.2.7.4.2.2.1   *TAS, transmission acknowledgement subfield in MD.* This 16-bit (17-32) downlink subfield in MD reports the segment numbers received so far in an uplink ELM sequence. Starting with bit 17, which denotes segment number 0, each of the following bits shall be set to ONE if the corresponding segment of the sequence has been received. TAS shall appear in MD if KE equals 1 in the same reply.

1.1.2.7.4.2.3   *Intermediate segment transfer.* The interrogator shall transfer intermediate segments by transmitting Comm-C interrogations with RC equals 1. The transponder shall store the segments and update TAS only if the setup of 1.1.2.7.4.2.1 is in effect and if the received NC is smaller than the value stored at

receipt of the initial segment. No reply shall be generated on receipt of an intermediate segment.

Note.— Intermediate segments may be transmitted in any order.

1.1.2.7.4.2.4   *Final segment transfer.* The interrogator shall transfer a final segment by transmitting a Comm-C interrogation with RC equals 2. The transponder shall store the content of the MC field and update TAS if the setup of 1.1.2.7.4.2.1 is in effect and if the received NC is smaller than the value of the initial segment NC. The transponder shall reply under all circumstances as per 1.1.2.7.4.2.5.

Note 1.— This final segment transfer interrogation can contain any message segment.

Note 2.— RC equals 2 is transmitted any time that the interrogator wants to receive the TAS subfield in the reply. Therefore, more than one "final" segment may be transferred during the delivery of an uplink ELM.

1.1.2.7.4.2.5   *Acknowledgement reply.* On receipt of a final segment, the transponder shall transmit a Comm-D reply (DF = 24), with KE equals 1 and with the TAS subfield in the MD field. This reply shall be transmitted at 128 microseconds plus or minus 0.25 microsecond following the sync phase reversal of the interrogation delivering the final segment.

1.1.2.7.4.2.6   *Completed message.* The transponder shall deem the message complete if all segments announced by NC in the initializing segment have been received. If the message is complete, the message content shall be delivered to the outside via the ELM interface of 1.1.2.10.5.2.1.3 and cleared. No later-arriving segments shall be stored. The TAS content shall remain unchanged until either a new setup is called for (1.1.2.7.4.2.1) or until closeout (1.1.2.7.4.2.8).

1.1.2.7.4.2.7   *C-timer restart.* The C-timer shall be restarted each time that a received segment is stored and the Comm-C II is not 0.

Note.— The requirement for the Comm-C II to be non-zero prevents the C-timer from being restarted during a non-selective uplink ELM transaction.

1.1.2.7.4.2.8   *Multisite uplink ELM closeout.* The interrogator shall close out a multisite uplink ELM by transmitting either a surveillance or a Comm-A interrogation containing:

either DI = 1

```
IIS     = assigned interrogator identifier
MES     = 2, 6 or 7 (uplink ELM closeout)

or DI = 0, 1 or 7

IIS     = assigned interrogator identifier
PC      = 5 (uplink ELM closeout)
```

The transponder shall compare the IIS of the interrogation to the Comm-C II and if the interrogator identifiers do not match, the state of the ELM uplink process shall not be changed. If the interrogator identifiers match, the transponder shall set the Comm-C II to 0, reset the C-timer, clear the stored TAS and discard any stored segments of an incomplete message.

1.1.2.7.4.2.9 *Automatic multisite uplink ELM closeout.* If the C-timer period expires before a multisite closeout has been accomplished the closeout actions described in 1.1.2.7.4.2.8 shall be initiated automatically by the transponder.

1.1.2.7.5 *NON-SELECTIVE UPLINK ELM*

Note. In cases where the multisite protocols are not required (for example, no overlapping coverage or sensor coordination via ground-to-ground communication), the non-selective uplink ELM protocol may be used.

Non-selective uplink ELM delivery shall take place as for multisite uplink ELMs described in 1.1.2.7.4.2. The interrogator shall close out an uplink ELM by transmitting PC equals 5 (uplink ELM closeout) in a surveillance or Comm-A interrogation. On receipt of this command, the transponder shall perform closeout, unless the C-timer is running. If the C-timer is running, indicating that a multisite reservation is in effect, the closeout shall be accomplished as per 1.1.2.7.4.2.8. An uncompleted message, present when the closeout is accepted, shall be cancelled.

1.1.2.7.6 ENHANCED UPLINK ELM PROTOCOL

Note. The enhanced uplink ELM protocol provides a higher data link capacity by permitting parallel delivery of uplink ELM messages by up to sixteen interrogators, one for each II code. Operation without the need for multisite uplink ELM reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced uplink ELM protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.

1.1.2.7.6.1 *General*

1.1.2.7.6.1.1　　The interrogator shall determine from the data link capability report whether the transponder supports the enhanced protocols. If the enhanced protocols are not supported by both the interrogator and the transponder, the multisite reservation protocols specified in 1.1.2.7.4.1 shall be used.

Note.— If the enhanced protocols are supported, uplink ELMs delivered using the multisite protocol may be delivered without a prior reservation.

1.1.2.7.6.1.2　　If the transponder and the interrogator are equipped for the enhanced protocol, the interrogator shall use the enhanced uplink protocol.

1.1.2.7.6.1.3　　The transponder shall be capable of storing a sixteen-segment message for each of the sixteen II codes.

1.1.2.7.6.2　　*Reservation processing.* The transponder shall support reservation processing for each II code as specified in 1.1.2.7.4.1

Note 1.— Reservation processing is required for interrogators that do not support the enhanced protocol.

Note 2.— Since the transponder can process simultaneous uplink ELMs for all sixteen II codes, a reservation will always be granted.

1.1.2.7.6.3　　*Enhanced uplink ELM delivery and closeout.* The transponder shall process received segments separately by II code. For each value of II code, uplink ELM delivery and closeout shall be performed as specified in 1.1.2.7.4.2 except that the MD field used to transmit the technical acknowledgment shall also contain the 4-bit (33-36) IIS subfield.

Note.— The interrogator may use the II code contained in the technical acknowledgement in order to verify that it has received the correct technical acknowledgement.

1.1.2.7.7　　MULTISITE DOWNLINK ELM PROTOCOL

1.1.2.7.7.1　　*Initialization.* The transponder shall announce the presence of a downlink ELM of n segments by making the binary code corresponding to the decimal value $15 + n$ available for insertion in the DR field of a surveillance or Comm-B reply, DF equals 4, 5, 20, 21. This announcement shall remain active until the ELM is closed out (1.1.2.7.7.3, 1.7.8.1).

1.1.2.7.7.1.1   *Multisite downlink ELM reservation.* An interrogator shall request a reservation for extraction of a downlink ELM by transmitting a surveillance or Comm-A interrogation containing:

DI   =   1
IIS   =   assigned interrogator identifier
MES   =   3 or 6 (downlink ELM reservation request)

Note.— A multisite downlink ELM reservation request is normally accompanied by a downlink ELM reservation status request (RSS = 3). This causes the interrogator identifier of the reserved interrogator to be inserted in the UM field of the reply.

1.1.2.7.7.1.1.1   Protocol procedure in response to this interrogation shall depend upon the state of the D-timer which indicates if a downlink ELM reservation is active. This timer shall run for *TR* seconds.

Note 1.— The value of TR is given in 1.1.2.10.3.9.

(a) if the D-timer is not running, the transponder shall grant a reservation to the requesting interrogator by:

(i) storing the IIS of the interrogation as the Comm-D II; and

(ii) starting the D-timer;

A multisite downlink ELM reservation shall not be granted by the transponder unless a downlink ELM is waiting to be transmitted.

(b) if the D-timer is running and the IIS of the interrogation equals the Comm-D II, the transponder shall restart the D-timer; and

(c) if the D-timer is running and the IIS of the interrogation does not equal the Comm-D II, there shall be no change to the Comm-D II or D-timer.

Note 2.— In case *(c)* the reservation request has been denied.

1.1.2.7.7.1.1.2   An interrogator shall determine if it is the reserved site through coding in the UM field and, if so, it is authorized to request delivery of the downlink ELM. Otherwise, ELM activity shall not be started during this scan.

Note.— If the interrogator is not the reserved site, a new reservation request may be made during the next scan.

1.1.2.7.7.1.3   If downlink ELM activity is not completed on the current scan, the interrogator shall ensure that it still has a reservation before requesting additional segments on a subsequent scan.

1.1.2.7.7.1.2   *Multisite-directed downlink ELM transmissions.* To direct a downlink ELM message to a specific interrogator, the multisite downlink ELM protocol shall be used. When the D-timer is not running, the interrogator identifier of the desired destination shall be stored as the Comm-D II. Simultaneously, the D-timer shall be started and the DR code (1.1.2.7.7.1) shall be set. For a multisite-directed downlink ELM, the D-timer shall not automatically time out but shall continue to run until:

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

    (b) the message is cancelled (1.1.2.10.5.4) by the data link avionics.

Note.— The protocols of 1.1.2.7.7.1 will then result in the delivery of the message to the reserved site. The data link avionics may cancel the message if delivery to the reserved site cannot be accomplished.

1.1.2.7.7.2   *Delivery of downlink ELMs.* The interrogator shall extract a downlink ELM by transmitting a Comm-C interrogation with RC equals 3. This interrogation shall carry the SRS subfield which specifies the segments to be transmitted. On receipt of this request, the transponder shall transfer the requested segments by means of Comm-D replies with KE equals 0 and ND corresponding to the number of the segment in MD. The first segment shall be transmitted 128 microseconds plus or minus 0.25 microsecond following the sync phase reversal of the interrogation requesting delivery and subsequent segments shall be transmitted at a rate of one every 136 microseconds plus or minus 1 microsecond. If a request is received to transmit downlink ELM segments and no message is waiting, each reply segment shall contain all ZEROs in the MD field.

Note 1.— The requested segments may be transmitted in any order.

Note 2.— Segments lost in downlink transmissions will be requested again by the interrogator on a subsequent interrogation carrying the SRS subfield. This process is repeated until all segments have been transferred.

1.1.2.7.7.2.1   *SRS, segment request subfield in MC.* This 16-bit (9-24) uplink subfield in MC shall request the transponder to transfer downlink ELM segments. Starting with bit 9, which denotes segment number 0, each of the following bits shall be set to ONE if the transmission of the corresponding segment is requested. SRS shall appear in MC if RC equals 3 in the same interrogation.

1.1.2.7.7.2.2   D-timer restart. The D-timer shall be restarted each time that a request for Comm-D segments is received if the Comm-D II is non-zero.

Note.— The requirement for the Comm-D II to be non-zero prevents the D-timer from being restarted during a non-selective downlink ELM transaction.

1.1.2.7.7.3   Multisite downlink ELM closeout. The interrogator shall close out a multisite downlink ELM by transmitting either a surveillance or a Comm-A interrogation containing:

either DI ═ 1

IS   =   assigned interrogator identifier
MES ═   4, 5 or 7 (downlink ELM closeout)

or DI = 0, 1 or 7

IS   ═   assigned interrogator identifier
PC   ═   6 (downlink ELM closeout).

The transponder shall compare the IIS of the interrogation to the Comm-D II and if the interrogator identifiers do not match, the state of the downlink process shall not be changed. If the interrogator identifiers match, and if a request for transmission has been complied with at least once, the transponder shall set the Comm-D II to 0, reset the D-timer, clear the DR code for this message and clear the message itself. If another downlink ELM is waiting to be transmitted, the transponder shall set the DR code (if no Comm-B message is waiting to be delivered) so that the reply contains the announcement of the next message.

1.1.2.7.7.4   Automatic expiration of downlink ELM reservation. If the D-timer period expires before a multisite closeout has been accomplished, the Comm-D II shall be set to 0, and the D-timer reset. The message and DR code shall not be cleared.

Note.— This makes it possible for another site to read and clear this message.

1.1.2.7.8   NON-SELECTIVE DOWNLINK ELM

Note.— In cases where the multisite protocols are not required (that is, no overlapping coverage or sensor coordination via ground-to-ground communication), the non-selective downlink ELM protocol may be used.

Non-selective downlink ELM delivery shall take place as described in 1.1.2.7.7.2.

1.1.2.7.8.1   *Non-selective downlink ELM closeout.* The interrogator shall close out a non-selective downlink ELM by transmitting PC equals 6 (downlink ELM closeout) in a surveillance or Comm-A interrogation. On receipt of this command, and if a request for transmission has been complied with at least once, the transponder shall

perform closeout unless the D-timer is running. If the D-timer is running, indicating that a multisite reservation is in effect, the closeout shall be accomplished as per 1.1.2.7.7.3.

1.1.2.7.9   ENHANCED DOWNLINK ELM PROTOCOL

Note.— The enhanced downlink ELM protocol provides a higher data link capacity by permitting parallel delivery of downlink ELM messages by up to sixteen interrogators, one for each II code. Operation without the need for multisite downlink ELM reservations is possible in regions of overlapping coverage for interrogators equipped for the enhanced downlink ELM protocol. The protocol is fully conformant to the standard multisite protocol and thus is compatible with interrogators that are not equipped for the enhanced protocol.

1.1.2.7.9.1   *General*

1.1.2.7.9.1.1   The interrogator shall determine from the data link capability report whether the transponder supports the enhanced protocols. If the enhanced protocols are not supported by both the interrogator and the transponder, the multisite reservation protocols specified in 1.1.2.6.11 shall be used for multisite and multisite-directed downlink ELMs.

Note.— If the enhanced protocols are supported, downlink ELMs delivered using the multisite-directed protocol can be delivered without a prior reservation.

1.1.2.7.9.1.2   If the transponder and the interrogator are equipped for the enhanced protocol, the interrogator shall use the enhanced downlink protocol.

1.1.2.7.9.2   *Enhanced multisite downlink ELM protocol*

1.1.2.7.9.2.1   The transponder shall be capable of storing a sixteen-segment message for each of the sixteen II codes.

1.1.2.7.9.2.2   Initialization. A multisite message input into the transponder shall be stored in the registers assigned to II = 0.

1.1.2.7.9.2.3   *Announcement and extraction.* A waiting multisite downlink ELM message shall be announced in the DR field of the replies to all interrogators for which a multisite directed downlink ELM message is not waiting. The UM field of the announcement reply shall indicate that the message is not reserved for any II code, that is, the IIS subfield shall be set to 0. When a command to reserve this message is received from a given interrogator, the message shall be reserved for the II code contained in the interrogation from that interrogator. After readout and until closeout, the message shall continue to be assigned to that II code.

Once a message is assigned to a specific II code, announcement of this message shall no longer be made in the replies to interrogators with other II codes. If the message is not closed out by the associated interrogator for the period of the D-timer, the message shall revert to multisite status and the process shall repeat. Only one multisite downlink ELM message shall be in process at a time.

1.1.2.7.9.2.4 *Closeout.* A closeout for a multisite message shall only be accepted from the interrogator that was assigned most recently to transfer the message.

1.1.2.7.9.2.5 *Announcement of the next message waiting.* The DR field shall indicate a message waiting in the reply to an interrogation containing a downlink ELM closeout if an unassigned multisite downlink ELM is waiting, or if a multisite directed message is waiting for that II code (1.1.2.7.9.2).

1.1.2.7.9.3 *Enhanced multisite directed downlink ELM protocol*

1.1.2.7.9.3.1 *Initialization.* When a multisite directed message is input into the transponder, it shall be placed in the downlink ELM registers assigned to the II code specified for the message. If the registers for this II code are already in use (that is, a multisite directed downlink ELM message is already in process for this II code), the new message shall be queued until the current transaction with that II code is closed out.

1.1.2.7.9.3.2 *Announcement. Announcement of a downlink ELM message waiting transfer shall be made using* the DR field as specified in 1.1.2.7.7.1 with the destination interrogator II code contained in the IIS subfield as specified in 1.1.2.6.5.3.2. The DR field and IIS subfield contents shall be set specifically for the interrogator that is to receive the reply. A waiting multisite directed message shall only be announced in the replies to the intended interrogator. It shall not be announced in replies to other interrogators.

1.1.2.7.9.3.3 *Delivery.* An interrogator shall determine if it is the reserved site through coding in the UM field. The delivery shall only be requested if it is the reserved site and shall be as specified in 1.1.2.7.7.2. The transponder shall transmit the message contained in the buffer associated with the II code specified in the IIS subfield of the segment request interrogation.

1.1.2.7.9.3.4 *Closeout.* Closeout shall be accomplished as specified in 1.1.2.7.7.3 except that a message closeout shall only be accepted from the interrogator with a II code equal to the one that transferred the message.

1.1.2.7.9.3.5   *Announcement of the next message waiting.* The DR field shall indicate a message waiting in the reply to an interrogation containing a downlink ELM closeout if another multisite directed message is waiting for that II code, or if a downlink message is waiting that has not been assigned a II code (1.1.2.7.9.2).

1.1.2.7.9.4   *Enhanced non-selective downlink ELM protocol.* The availability of a non-selective downlink ELM message shall be announced to all interrogators. Otherwise, the protocol shall be as specified in 1.1.2.7.7.

1.1.2.8   AIR-AIR SERVICE AND SQUITTER TRANSACTIONS

Note.   Airborne collision avoidance system (ACAS) equipment uses the formats UF or DF equals 0 or 16 for air-air surveillance.

1.1.2.8.1   SHORT AIR-AIR SURVEILLANCE, UPLINK FORMAT 0
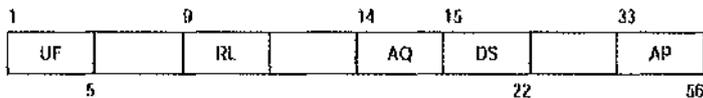
1		9		14	15		33	
UF		RL		AQ	DS		AP	
5					22		56	

The format of this interrogation shall consist of these fields:

Field	Reference
UF uplink format Spare- 3 bits	1.1.2.3.2.1.1
RL reply length Spare bits- 4 bits	1.1.2.8.1.2
AQ acquisition	1.1.2.8.1.1
DS data selector Spare- 10 bits	1.1.2.8.1.3
AP Address/parity	1.1.2.3.2.1.3

1.1.2.8.1.1   *AQ: Acquisition.* This 1-bit (14) uplink field shall contain a code which controls the content of the RI field.

1.1.2.8.1.2   *RL: Reply length.* This 1-bit (9) uplink field shall command the format to be used for the reply.

Coding
0   signifies a reply with DF = 0
1   signifies a reply with DF = 16

Note.— A transponder that does not support DF = 16 (that is, transponder which does not support the ACAS cross-link capability and is not associated with airborne collision avoidance equipment) would not reply to a UF= 0 interrogation with RL=1.

1.1.2.8.1.3   *DS: Data selector.* This 8-bit (15-22) uplink field shall contain the BDS code (1.1.2.6.11.2.1) of the GICB register whose contents shall be returned to the corresponding reply with DF = 16.

1.1.2.8.2   SHORT AIR-AIR SURVEILLANCE, DOWNLINK FORMAT 0
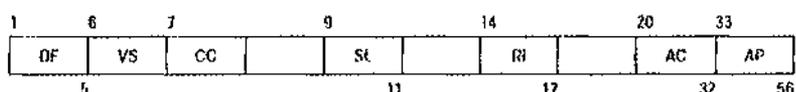
This reply shall be sent in response to an interrogation with UF equals 0 and RL equals 0. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
VS vertical status	1.1.2.8.2.1
CC cross-link capability	1.1.2.8.2.3
Spare- 1 bit	
SL sensitivity level, ACAS	1.1.2.1.5
Spare - 2 bits	
RI reply information	1.1.2.8.2.2
Spare bits- 2 bits	
AC altitude code	1.1.2.6.5.4
AP Address/parity	1.1.2.3.2.1.3

1.1.2.8.2.1   *VS: Vertical status:* This 1-bit (6) downlink field shall indicate the status of the aircraft (1.1.2.6.10.1.2).

Coding
0   signifies that the aircraft is airborne
1   signifies that the aircraft is on the ground

1.1.2.8.2.2   *RI: Reply information, air-air.* This 4-bit (14-17) downlink field shall report the aircraft's maximum cruising true airspeed capability and type of reply to interrogating aircraft. The coding shall be as follows:

0   signifies a reply to an air-air interrogation UF = 0 with AQ = 0, no operating ACAS

1-7   reserved for ACAS

8-15 signifies a reply to an air-air interrogation UF = 0 with AQ = 1 and that the maximum airspeed is as follows:

8   no maximum airspeed data available

9   maximum airspeed is .LE. 140 km/h (75 kt)

10   maximum airspeed is .GT. 140 and .LE. 280 km/h (75 and 150 kt)

11   maximum airspeed is .GT. 280 and .LE. 560 km/h (150 and 300 kt)

12   maximum airspeed is .GT. 560 and .LE. 1 110 km/h (300 and 600 kt)

13   maximum airspeed is .GT. 1 110 and .LE. 2 220 km/h (600 and 1 200 kt)

14   maximum airspeed is more than 2 220 km/h (1 200 kt)

15   not assigned.

Note.— ".LE." means "less than or equal to" and ".GT." means "greater than".

1.1.2.8.2.3   *CC: Cross-link capability.* This 1-bit (7) downlink field shall indicate the ability of the transponder to support the cross-link capability, that is, decode the contents of the DS field in an interrogation with UF equals 0 and respond with the contents of the specified GICB register in the corresponding reply with DF equals 16.

Coding

0 signifies that the transponder cannot support the cross-link capability
1 signifies that the transponder supports the cross-link capability.

1.1.2.8.3   LONG AIR-AIR SURVEILLANCE, DOWNLINK FORMAT 16

1	6	9	14	20	33	89		
DF	VS	SL	RI	AC	MV	AP		
6		11	17	32	88	112		
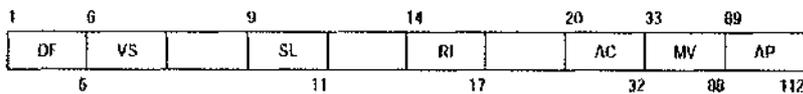
This reply shall be sent in response to an interrogation with UF equals 0 and RL equals 1. The format of this reply shall consist of these fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
VS vertical status Spare- 2 bits	1.1.2.8.2.1
SL sensitivity level, ACAS Spare - 2 bits	1.1.2.1.5
RI reply information Spare bits- 2 bits	1.1.2.8.2.2

AC altitude code	1.1.2.6.5.4
MV message, ACAS	1.1.2.8.3.1
AP Address/parity	1.1.2.3.2.1.3

1.1.2.8.3.1   *MV: Message, ACAS.* This 56-bit (33–88) downlink field shall contain GICB information as requested in the DS field of the UF 0 interrogation that elicited the reply.

Note.— The MV field is also used by ACAS for air-air coordination

1.1.2.8.4   AIR-AIR TRANSACTION PROTOCOL

Note.- Interrogation-reply coordination for the air-air formats follows the protocol outlined in Table 1-7 in Schedule 1 (1.1.2.4.1.3.2.2).

The most significant bit (bit 14) of the RI field of an air-air reply shall replicate the value of the AQ field (bit 14) received in an interrogation with UF equals 0.
If AQ equals 0 in the interrogation, the RI field of the reply shall contain the value 0.
If AQ equals 1 in the interrogation, the RI field of the reply shall contain the maximum cruising true airspeed capability of the aircraft as defined in 1.1.2.8.2.2.

In response to a UF = 0 with RL = 1 and DS ≠ 0, the transponder shall reply with a DF = 16 reply in which the MV field shall contain the contents of the GICB register designated by the DS value. In response to a UF = 0 with RL = 1 and DS = 0, the transponder shall reply with a DF = 16 with an MV field of all zeros. Receipt of a UF = 0 with DS ≠ 0 but RL = 0 shall have no associated ACAS cross-link action, and the transponder shall reply as specified in 1.1.2.8.2.2.

1.1.2.8.5   ACQUISITION SQUITTER

Note.— SSR Mode S transponders transmit acquisition squitters (unsolicited downlink transmissions) to permit passive acquisition by interrogators with broad antenna beams, where active acquisition may be hindered by all-call synchronous garble. Examples of such interrogators are an airborne collision avoidance system and an airport surface surveillance system.

1.1.2.8.5.1   *Acquisition squitter format.* The format used for acquisition squitter transmissions shall be the all-call reply, (DF – 11) with II · 0.

1.1.2.8.5.2   *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 (1.1.2.4.1);

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

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

(d) acquisition squitters shall only be transmitted on the surface if the transponder is not reporting the surface position type of Mode S extended squitter. 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 (1.1.2.8.6.7).

1.1.2.8.5.3 *Acquisition squitter antenna selection.* Transponders operating with antenna diversity (1.1.2.10.4) shall transmit acquisition squitters as follows —

   (a) when airborne (1.1.2.8.6.7), the transponder shall transmit acquisition squitters alternately from the two antennas; and

   (b) when on the surface (1.1.2.8.6.7), the transponder shall transmit acquisition squitters under control of SAS (1.1.2.6.1.4.1 f)). In the absence of any SAS commands, use of the top antenna only shall be the default.

Note.— Acquisition squitters are not emitted on the surface if the transponder is reporting the surface type of extended squitter (1.1.2.8.6.4.3).

1.1.2.8.6   EXTENDED SQUITTER, DOWNLINK FORMAT 17

1	6	9	33	89
DF	CA	AA	ME	PI
5	8	32	88	112

Note.   SSR Mode S transponders transmit extended squitters to support the broadcast of aircraft-derived position for surveillance purposes. The broadcast of this type of

information is a form of automatic dependent surveillance (ADS) known as ADS-broadcast (ADS-B).

1.1.2.8.6.1 *Extended squitter format.* The format used for the extended squitter shall be a 112-bit downlink format

(DF = 17) containing the following fields:

Field	Reference
DF downlink format	1.1.2.3.2.1.2
CA capability	1.1.2.5.2.2.1
AA address, announced	1.1.2.5.2.2.2
ME message, extended squitter	1.1.2.8.6.2
PI parity/interrogator identifier	1.1.2.3.2.1.4

1.1.2.8.6.2 *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 or version 1 message formats as described below –

(a) Version 0 ES message formats and related requirements are suitable for early implementation of extended squitter applications. Surveillance quality is reported 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; or

(b) Version 1 ES message formats and related requirements apply to more advanced ADS-B applications. Surveillance accuracy and integrity are reported 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.

Note 1.— The formats and update rates of each register are specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

Note 2.— The formats for the two versions are interoperable. An extended squitter receiver can recognize and decode both version 0 and version 1 message formats.

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

1.1.2.8.6.3 *Extended squitter types*

1.1.2.8.6.3.1 *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 (1.1.2.6.11.2) containing RR equals 16 and DI equals 7 and RRS equals 5 will cause the resulting reply to contain the airborne position report in its MB field.

1.1.2.8.6.3.1.1 *SSS, surveillance status subfield in ME.* The transponder shall report the surveillance status of the transponder in this 2-bit (38, 39) subfield of ME when ME contains an airborne position squitter report.

Coding

0   signifies no status information
1   signifies transponder reporting permanent alert condition
2   signifies transponder reporting a temporary alert condition
3   signifies transponder reporting SPI condition

Codes 1 and 2 shall take precedence over code 3.

1.1.2.8.6.3.1.2 *ACS, altitude code subfield in ME.* Under control of ATS (1.1.2.8.6.3.1.3), the transponder shall report either navigation-derived altitude, or the barometric altitude code in this 12-bit (41-52) subfield of ME when ME contains an airborne position report. When barometric altitude is reported, the contents of the ACS shall be as specified for the 13-bit AC field (1.1.2.6.5.4) except that the M-bit (bit 26) shall be omitted.

1.1.2.8.6.3.1.3 *Control of ACS reporting.* Transponder reporting of altitude data in ACS shall depend on the altitude type subfield (ATS) as specified in 1.1.2.8.6.8.2. 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.

1.1.2.8.6.3.1.4 *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 containing RR equals 16 and DI equals 7 and RRS equals 6 will cause the resulting reply to contain the surface position report in its MB field.

1.1.2.8.6.3.2 *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 containing RR equals 16 and DI equals 7 and RRS equals 8 will cause the resulting reply to contain the aircraft identification report in its MB field.

1.1.2.8.6.3.3   *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 containing RR equals 16 and DI equals 7 and RRS equals 9 will cause
the resulting reply to contain the airborne velocity report in its MB field.

1.1.2.8.6.3.4   *Periodic status and event-driven squitters*

1.1.2.8.6.3.4.1   *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 (1.1.2.6.11.2) 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 (1.1.2.6.11.2) 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.

1.1.2.8.6.3.4.2   *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 (1.1.2.6.11.2) 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.

1.1.2.8.6.4   *Extended squitter rate*

1.1.2.8.6.4.1   *Initialization.* At power up initialization, the transponder shall commence operation in a mode in which it broadcasts only acquisition squitters (1.1.2.8.5). 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. Acquisition squitters shall always be reported if position or velocity extended squitters are not reported.

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 a squitter type stops for 60 seconds, broadcast of that extended squitter type will be discontinued until data insertion is resumed.

Note 2.— After timeout (1.1.2.8.6.6), this squitter type may contain an ME field of all zeroes.

1.1.2.8.6.4.2   *Airborne position squitter rate.* Airborne position squitter transmissions shall be emitted when the aircraft is airborne (1.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne position squitter, with the exceptions as specified in 1.1.2.8.6.4.7.

1.1.2.8.6.4.3   *Surface position squitter rate.* Surface position squitter transmissions shall be emitted when the aircraft is on the surface (1.1.2.8.6.7) using one of two rates depending upon whether the high or low squitter rate has been selected (1.1.2.8.6.9). 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 1.1.2.8.6.4.7.

1.1.2.8.6.4.4   *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 1.1.2.8.6.4.7.

1.1.2.8.6.4.5   *Airborne velocity squitter rate.* Airborne velocity squitter transmissions shall be emitted when the aircraft is airborne (1.1.2.8.6.7) at random intervals that are uniformly distributed over the range from 0.4 to 0.6 seconds using a time quantization of no greater than 15 milliseconds relative to the previous airborne velocity squitter, with the exceptions as specified in 1.1.2.8.6.4.7.

1.1.2.8.6.4.6   *Periodic status and event-driven squitter rates*

1.1.2.8.6.4.6.1   *Periodic status squitter rates.* The periodic status squitter types supported by a Mode S extended squitter transmitting system class, as specified in regulation 59 (2) shall be periodically emitted at defined intervals depending on the on-the-ground status and whether their content has changed.

Note.— 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).

1.1.2.8.6.4.6.2   *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 1.1.2.8.6.4.7. 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.

Note.— The squitter transmission rate and the duration of squitter transmissions is application-dependent. Choices made for each application must consider interference considerations as shown in the Aeronautical Surveillance Manual (Doc 9924).

1.1.2.8.6.4.7   *Delayed transmission.* Extended squitter transmission shall be delayed in the following circumstances –

    (a) if the transponder is in a transaction cycle (1.1.2.4.1);

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

    (c) if a mutual suppression interface is active.

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

1.1.2.8.6.5 *Extended squitter antenna selection.* Transponders operating with antenna diversity (1.1.2.10.4) shall transmit extended squitters as follows –

    (a) when airborne (1.1.2.8.6.7), the transponder shall transmit each type of extended squitter alternately from the two antennas; and

    (b) when on the surface (1.1.2.8.6.7), the transponder shall transmit extended squitters under control of SAS (1.1.2.6.1.4.1 f)).

In the absence of any SAS commands, use of the top antenna only shall be the default condition.

1.1.2.8.6.6 *Register time-out.* The transponder shall clear all 56-bits of the airborne position, surface position, squitter status and airborne velocity information transponder registers 05, 06, 07 and 09 {HEX} if these registers are not updated within two seconds of the previous update. This time-out shall be determined separately for each of these registers.

Note 1.— Termination of extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871).

Note 2.— These registers are cleared to prevent the reporting of outdated position, velocity and squitter rate information.

1.1.2.8.6.7 *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 1-9 Schedule 1. 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 set and report the on-the-ground status (and therefore broadcast the surface type format) as commanded by control codes in TCS (1.1.2.6.1.4.1 f)). After time-out of the TCS commands, control of airborne/surface determination shall revert to the means described above.

Note.— 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 on-the-ground status will be commanded to set and report the on-the-ground status via TCS (1.1.2.6.1.4.1 f)). The normal return to aircraft control of the vertical status is via a ground command to cancel the on-the-ground

status. To guard against loss of communications after take-off, commands to set and report the on-the-ground status automatically time-out.

1.1.2.8.6.8   *Squitter status reporting.* A GICB request (1.1.2.6.11.2) containing RR equals 16 and DI equals 7 and RRS equals 7 shall cause the resulting reply to contain the squitter status report in its MB field.

1.1.2.8.6.8.1   *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 0716 in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871).

1.1.2.8.6.8.2   *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 (1.1.2.8.6.3.1.2) of transponder register 05 {HEX}.
1   signifies that navigation-derived altitude shall be reported in the ACS (1.1.2.8.6.3.1.2) 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 (ICAO Doc 9871).

1.1.2.8.6.9   *Surface squitter rate control.* Surface squitter rate shall be determined as follows —

(a) once per second the contents of the TRS shall be read. If the value of TRS is 0 or 1, the transponder shall transmit surface squitters at the high rate. If the

value of TRS is 2, the transponder shall transmit surface squitters at the low rate;

(b) the squitter rate determined via TRS shall be subject to being overridden by commands received via RCS (1.1.2.6.1.4.1 f)). RCS code 1 shall cause the transponder to squitter at the high rate for 60 seconds. RCS code 2 shall cause the transponder to squitter at the low rate for 60 seconds. These commands shall be able to be refreshed for a new 60 second period before time-out of the prior period; and

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

1.1.2.8.6.10   *Latitude/longitude coding using compact position reporting (CPR).* Mode S extended squitter shall use compact position reporting (CPR) to encode latitude and longitude efficiently into messages.

Note.— The method used to encode/decode CPR is specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.8.6.11   *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, 1.1.2.8.6.8.2) 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.

1.1.2.8.7   EXTENDED SQUITTER/SUPPLEMENTARY, DOWNLINK FORMAT 18

10010	CF:3			PI:24

Note 1.— This format supports the broadcast of extended squitter ADS-B messages by non-transponder devices, that is, they are not incorporated into a Mode S transponder. A separate format is used to clearly identify this non-transponder case to prevent ACAS II or extended squitter ground stations from attempting to interrogate these devices.

Note 2.— This format is also used for ground broadcast of ADS-B related services such as traffic information broadcast (TIS-B).

Note 3.— The format of the DF = 18 transmission is defined by the value of the CF field.

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

Field	Reference
DF downlink format	1.1.2.3.2.1.2
CF control field	1.1.2.8.7.2
PI parity/interrogator identifier	1.1.2.3.2.1.4

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

Code 0	=	ADS-B ES/NT devices that report the ICAO 24-bit address in the AA field (1.8.7)
Code 1	=	Reserved for ADS-B for ES/NT devices that use other addressing techniques in the AA field (1.1.2.8.7.3)
Code 2	=	Fine format TIS-B message
Code 3	=	Coarse format TIS-B message
Code 4	=	Reserved for TIS-B management messages
Code 5	=	TIS-B messages that relay ADS-B messages that use other addressing techniques in the AA field
Code 6	··	ADS-B rebroadcast using the same type codes and message formats as defined for DF = 17 ADS-B messages
Code 7	=	Reserved

1.1.2.8.7.3   ADS-B for extended squitter/non-transponder (ES/NT) devices

10010	CF=0	AA:24	ME:56	PI:24

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

Field	Reference
DF downlink format	1.1.2.3.2.1.2
CF control field=0	1.1.2.8.7.2

AA address, announced	1.1.2.5.2.2.2
ME message, extended squitter	1.1.2.8.6.2
PI parity/interrogator identifier	1.1.2.3.2.1.4

1.1.2.8.7.3.2   *ES/NT squitter types*

1.1.2.8.7.3.2.1   *Airborne position squitter.* The airborne position type ES/NT shall use format DF = 18 with the format for register 05 {HEX} as defined in 1.1.2.8.6.2 inserted in the ME field.

1.1.2.8.7.3.2.2   *Surface position squitter.* The surface position type ES/NT shall use format DF = 18 with the format for register 06 {HEX} as defined in 1.1.2.8.6.2 inserted in the ME field.

1.1.2.8.7.3.2.3   *Aircraft identification squitter.* The aircraft identification type ES/NT shall use format DF = 18 with the format for register 08 {HEX} as defined in 1.1.2.8.6.2 inserted in the ME field.

1.1.2.8.7.3.2.4   *Airborne velocity squitter.* The airborne velocity type ES/NT shall use format DF   18 with the format for register 09 {HEX} as defined in 1.1.2.8.6.2 inserted in the ME field.

1.1.2.8.7.3.2.5   *Periodic status and event-driven squitters*

1.1.2.8.7.3.2.5.1   *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 1.1.2.8.6.4.6.1 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 1.1.2.8.6.4.6.1 inserted in the ME field.

1.1.2.8.7.3.2.5.2   *Event-driven squitter.* The event-driven type ES/NT shall use format DF = 18 with the format for register 0A {HEX} as defined in 1.1.2.8.6.2 inserted in the ME field.

1.1.2.8.7.3.3   *ES/NT squitter rate.*

1.1.2.8.7.3.3.1   *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 1.1.2.8.6.4.2 to 1.1.2.8.6.4.6.

Note 1.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity. If input to the register for squitter types stops for 60 seconds, broadcast for this extended squitter type will cease until data insertion resumes, except for an ES/NT device operating on the surface (as specified for extended squitter Version 1 formats in the Technical Provisions for Mode S Services and Extended Squitter (Doc 9871).

Note 2.— After timeout (1.1.2.8.7.6) this squitter type may contain an ME field of all zeros.

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

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

1.1.2.8.7.3.3.4   *ES/NT antenna selection.* Non-transponder devices operating with antenna diversity (1.10.4) shall transmit ES/NT squitters as follows:

(a) when airborne (1.1.2.8.6.7), the non-transponder device shall transmit each type of ES/NT squitter alternately from the two antennas; and

(b) when on the surface (1.1.2.8.6.7), the non-transponder device shall transmit ES/NT squitters using the top antenna.

1.1.2.8.7.3.3.5   *Register timeout.* The non-transponder device shall clear all 56-bits of the airborne position, surface position and velocity registers used for these messages if these registers are not updated within two seconds of the previous update. This timeout shall be determined separately for each of these registers.

Note 1.— The termination of an extended squitter broadcast is specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

Note 2.— These registers are cleared to prevent the reporting of outdated position and velocity information.

1.1.2.8.7.3.3.6   *Airborne/surface state determination.* 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

1.1.2.6.10.3.1 and 1.1.2.8.6.7. Aircraft without such means shall report the airborne type message, except as specified in 1.1.2.8.6.7

1.1.2.8.7.3.3.7 *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 0716 in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.8.7.4 *Use of ES by other surveillance systems.*

1.1.2.8.7.4.1 *Surface system control*

When a surface surveillance system uses DF=18 as part of a surveillance function, it should not use the formats that have been allocated for the purpose of surveillance of aircraft, vehicles or obstacles.

Note 1.— The formats allocated for the purpose of surveillance of aircraft, vehicles or obstacles are specified in the Technical Provisions for Mode S Services and Extended Squitter ICAO Doc 9871).

Note 2.— The transmission of any message format used for conveying position, velocity, identification, state information, etc., may result in the initiation and maintenance of false tracks in other 1090ES receivers. The use of these messages for this purpose may be prohibited in the future.

1.1.2.8.7.4.2 *Surface system status-* The surface system status message type (Type Code=24) should be the only message used to provide the status or synchronization of surface surveillance systems.

Note.— The surface system status message is specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871). This message will be used only by the surface surveillance system that generated it and will be ignored by other surface systems.

1.1.2.8.8 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.

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

Field	Reference
DF downlink format	1.1.2.3.2.1.2
AF Control field	1.1.2.8.8.2

1.1.2.8.8.2 *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

1.1.2.8.9 EXTENDED SQUITTER MAXIMUM TRANSMISSION RATE

1.1.2.8.9.1 The maximum total number of extended squitters (DF = 17, 18 and 19) emitted by any extended squitter installation shall not exceed 6.2 per second, except as specified in 1.1.2.8.9.2.

1.1.2.8.9.2 For installations capable of emitting DF = 19 squitters and in accordance with 1.1.2.8.8, transmission rates for lower power DF = 19 squitters shall be limited to a peak of forty DF = 19 squitters per second, and thirty DF = 19 squitters per second averaged over 10 seconds, provided that the maximum total squitter power-rate product for the sum of full power DF = 17 squitters, full power DF = 18 squitters, full power DF = 19 squitters, and lower power DF = 19 squitters, is maintained at or below a level equivalent to the power sum of 6.2 full power squitters per second averaged over 10 seconds.

1.1.2.8.9.3 The Authority shall ensure that the use of low power and higher rate DF = 19 operation (as per 1.1.2.8.9.2) is compliant with the following requirements –

(a) it is limited to formation or element lead aircraft engaged in formation flight, directing the messages toward wing and other lead aircraft through a directional antenna with a beam-width of no more than 90 degrees; and

(b) the type of information contained in the DF = 19 message is limited to the same type of information in the DF = 17 message, that is, information for the sole purpose of safety-of-flight.

Note.— This low-power, higher squitter rate capability is intended for limited use by State aircraft in coordination with appropriate regulatory bodies.

1.1.2.8.9.4   All UF = 19 airborne interrogations shall be included in the interference control
provisions of 1.1.2.2.2.2.

1.1.2.9   AIRCRAFT IDENTIFICATION PROTOCOL

1.1.2.9.1   *Aircraft identification reporting.* A ground-initiated Comm-B request (1.1.2.6.11.2)
containing RR equals 18 and either DI does not equal 7 or DI equals 7 and RRS
equals 0 shall cause the resulting reply to contain the aircraft identification in its MB
field.

1.1.2.9.1.1   *AIS, aircraft identification subfield in MB.* The transponder shall report the aircraft
identification in the 48-bit (41-88) AIS subfield of MB. The aircraft identification
transmitted shall be that employed in the flight plan. When no flight plan is
available, the registration marking of the aircraft shall be inserted in this subfield.

Note.— When the registration marking of the aircraft is used, it is classified as
"fixed direct data". When another type of aircraft identification is used, it is
classified as "variable direct data".

1.1.2.9.1.2   *Coding of the AIS subfield.* The AIS subfield shall be coded as follows:

33	41	47	53	59	65	71	77	83
BDS	Char. 1	Char. 2	Char. 3	Char. 4	Char. 5	Char. 6	Char. 7	Char. 8
40	48	52	58	64	70	76	82	88

Note.— Aircraft identification coding provides up to eight characters.

The BDS code for the aircraft identification message shall be BDS1 equals 2 (33-36) and BDS2
equals 0 (37-40). Each character shall be coded as a 6-bit subset of the International Alphabet
Number 5 (IA-5) as illustrated in Table 1-8. The character code shall be transmitted with the
high order unit (*b6*) first and the reported aircraft identification shall be transmitted with its left-
most character first. Characters shall be coded consecutively without intervening SPACE code.
Any unused character spaces at the end of the subfield shall contain a SPACE character code.

1.1.2.9.1.3   *Aircraft identification capability report.* Transponders which respond to a ground-
initiated request for aircraft identification shall report this capability in the data
link capability report (1.1.2.6.10.2.2.2) by setting bit 33 of the MB subfield to 1.

1.1.2.9.1.4   *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 1.6.11.4 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.— 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 identification failure (e.g. the loss of the interface providing flight identification).

1.1.2.10   Essential System Characteristics of the SSR Mode S Transponder

1.1.2.10.1.   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 1.1.2.4, 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. 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 or transmitter components from becoming an integral part of the antenna subassembly.

1.1.2.10.1.1.   Reply ratio in the presence of interference

Note.— The following paragraphs present measures of the performance of the Mode S transponder in the presence of interfering Mode A/C interrogation pulses and low-level in-band CW interference.

1.1.2.10.1.1.1.   *Reply ratio in the presence of an interfering pulse*. Given a Mode S interrogation which requires a reply (1.4), the reply ratio of a transponder shall be at least 95 per cent in the presence of an interfering Mode A/C interrogation pulse if the level of the interfering pulse is 6 dB or more below the signal level for Mode S input signal levels between −68 dBm and −21 dBm and the interfering pulse overlaps the *P6* pulse of the Mode S interrogation anywhere after the sync phase reversal. Under the same conditions, the reply ratio shall

be at least 50 per cent if the interference pulse level is 3 dB or more below the signal level.

1.1.2.10.1.1.2.   *Reply ratio in the presence of pulse pair interference.* Given an interrogation which requires a reply (1.4), 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.

1.1.2.10.1.1.3.   *Reply ratio in the presence of low level asynchronous interference.* For all received signals between –65 dBm and –21 dBm and given a Mode S interrogation that requires a reply according to 1.4 and if no lockout condition is in effect, the transponder shall reply correctly with at least 95 per cent reply ratio in the presence of asynchronous interference. Asynchronous interference shall be taken to be a single Mode A/C interrogation pulse occurring at all repetition rates up to 10 000 Hz at a level 12 dB or more below the level of the Mode S signal.

Note.— Such pulses may combine with the P1 and P2 pulses of the Mode S interrogation to form a valid Mode A/C-only all-call interrogation. The Mode S transponder does not respond to Mode A/C-only all-call interrogations. A preceding pulse may also combine with the P2 of the Mode S interrogation to form a valid Mode A or Mode C interrogation. However, the P1 – P2 pair of the Mode S preamble takes precedence. The Mode S decoding process is independent of the Mode A/Mode C decoding process and the Mode S interrogation is accepted.

1.1.2.10.1.1.4.   *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.

1.1.2.10.1.1.5.   *Spurious response*

1.1.2.10.1.1.5.1.   The response to signals not within the receiver pass band shall be at least 60 dB below normal sensitivity.

1.1.2.10.1.1.5.2.   For equipment certified after 1 January 2011, the spurious Mode A/C reply ratio generated by 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).

1.1.2.10.2.   *Transponder peak pulse power.* The peak power of each pulse of a reply shall

(a) not be less than 18.5 dBW for aircraft not capable of operating at altitudes exceeding 4 570 m (15 000 ft);

(b) not be less than 21.0 dBW for aircraft capable of operating above 4 570 m (15 000 ft);

(c) not be less than 21.0 dBW for aircraft with maximum cruising speed exceeding 324 km/h (175 kt); and

(d) not exceed 27.0 dBW.

1.1.2.10.2.1.   *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 shall not exceed –50 dBm. The inactive state is defined to include the entire period between transmissions less 10-microsecond transition periods preceding the first pulse and following the last pulse of the transmission.

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 necessary to further constrain the inactive state transponder power.

1.1.2.10.2.2.   *Spurious emission radiation*

CW radiation shall not exceed 70 dB below 1 watt.

1.1.2.10.3. SPECIAL CHARACTERISTICS

1.1.2.10.3.1. Mode S side-lobe suppression

Note.— Side-lobe suppression for Mode S formats occurs when a P5 pulse overlays the location of the sync phase reversal of P6, causing the transponder to fail to recognize the interrogation.

Given a Mode S interrogation that requires a reply, the transponder shall —

(a) at all signal levels between MTL +3 dB and –21 dBm, have a reply ratio of less than 10 per cent if the received amplitude of $P5$ exceeds the received amplitude of $P6$ by 3 dB or more; and

(b) at all signal levels between MTL +3 dB and –21 dBm, have a reply ratio of at least 99 per cent if the received amplitude of $P6$ exceeds the received amplitude of $P5$ by 12 dB or more.

1.1.2.10.3.2. *Mode S dead time.* Dead time shall be defined as the time interval beginning at the end of a reply transmission and ending when the transponder has regained sensitivity to within 3 dB of MTL. Mode S transponders shall not have more than 125 microseconds' dead time.

1.1.2.10.3.3. *Mode S receiver desensitization.* The transponder's receiver shall be desensitized according to 1.1.1.7.7.1 on receipt of any pulse of more than 0.7 microseconds duration.

1.1.2.10.3.3.1. *Recovery from desensitization.* Recovery from desensitization shall begin at the trailing edge of each pulse of a received signal and shall occur at the rate determined 1.1.1.2.7.2, provided that no reply or data transfer is made in response to the received signal.

1.1.2.10.3.4. Recovery after Mode S interrogations that do not elicit replies

1.1.2.10.3.4.1. Recovery after a single Mode S interrogation

1.1.2.10.3.4.1.1. The transponder shall recover sensitivity to within 3 dB of MTL, no later than 128 microseconds after receipt of the sync phase reversal following a Mode S interrogation that is not accepted or that is accepted but requires no reply.

1.1.2.10.3.4.1.2. The transponder 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 or that is accepted but requires no reply.

1.1.2.10.3.4.1.3.   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 or that is accepted but requires no reply.

1.1.2.10.3.4.2.   *Recovery after a Mode S Comm-C interrogation.* A Mode S transponder with Comm-C capability shall recover sensitivity to within 3 dB of MTL no later than 45 microseconds after receipt of the sync phase reversal following acceptance of a Comm-C interrogation for which no reply is required.

1.1.2.10.3.5.   *Unwanted Mode S replies.* Mode S transponders shall not generate unwanted Mode S replies more often than once in 10 seconds. Installation in the aircraft shall be made in such a manner that this standard shall be achieved when all possible interfering equipments installed in the same aircraft are operating at maximum interference levels.

1.1.2.10.3.5.1.   *Unwanted Mode S replies 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 and at signal levels of -60 dBm or less, and in the absence of valid interrogation signals, Mode S transponders shall not generate unwanted Mode S replies more often than once per 10 seconds.

1.1.2.10.3.6.   Reply rate limiting

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

1.1.2.10.3.6.1.   *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 shall permit the minimum reply rates required in 1.1.2.10.3.7.2 and 1.1.2.10.3.7.3.

1.1.2.10.3.6.2.   *Modes A and C reply rate limiting.* Reply rate limiting for Modes A and C shall be affected according to 1.1.1.7.9.1. The determined sensitivity reduction shall not affect the Mode S performance of the transponder.

1.1.2.10.3.7.   Minimum reply rate capability, Modes A, C and S

1.1.2.10.3.7.1.   All reply rates specified in 1.1.2.10.3.7 shall be in addition to any squitter transmissions that the transponder is required to make.

1.1.2.10.3.7.2.   Minimum reply rate capability, Modes A and C. The minimum reply rate capability for Modes A and C shall be in accordance with 1.1.1.7.9.

1.1.2.10.3.7.3.   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 –

50	Mode S replies in any 1-second interval;
18	Mode S replies in a 100-millisecond interval;
8	Mode S replies in a 25-millisecond interval; or
4	Mode S replies in a 1.6-millisecond interval;

In addition to any downlink ELM transmissions, a level 2, 3 or 4 transponder shall be able to generate as long replies at least –

(a) 16 of 50 Mode S replies in any 1-second interval;

(b) 6 of 18 Mode S replies in a 100-millisecond interval;

(c) of 8 Mode S replies in a 25-millisecond interval; and

(d) of 4 Mode S replies in a 1.6-millisecond interval;

Transponders used in conjunction with ACAS shall be able to generate as long replies at least –

(a) 60 Mode S replies in any 1-second interval;

(b) 6 of 18 Mode S replies in a 100-millisecond interval;

(c) of 8 Mode S replies in a 25-millisecond interval ;and

(d) of 4 Mode S replies in a 1.6-millisecond interval;

In addition to downlink ELM transmissions, a level 5 transponder shall be able to generate as long replies at least –

(a) 24 of 50 Mode S replies in any 1-second interval;

(b) of 18 Mode S replies in a 100-millisecond interval;

(c) 6 of 8 Mode S replies in a 25-millisecond interval; and

(d) of 4 Mode S replies in a 1.6-millisecond interval

1.1.2.10.3.7.4.   Minimum Mode S ELM peak reply rate

Note 1.— When a downlink ELM is initialized,, the Mode S transponder announces the length (in segments) of the waiting message. The transponder must be able to transmit this number of segments, plus an additional margin to make up for missed replies, during the beam dwell of the ground interrogator.

At least once every second a Mode S transponder equipped for ELM downlink operation shall be capable of transmitting in a 25-millisecond interval, at least 25 per cent more segments than have been announced in the initialization The minimum length downlink ELM capability for level 4 and 5 transponders shall be as specified in 1.1.2.10.5.2.2.2.

Note 2.— A transponder capable of processing the maximum length downlink ELM (16 segments) is therefore required to be able to transmit 20 long replies under the above conditions. Level 4 transponders may be built which process less than the maximum message length. These transponders cannot initialize a message length that exceeds their transmitter capability. For example, a transponder that can transmit at most 10 long replies under the above conditions can never announce a message of more than 8 segments.

1.1.2.10.3.8.   Reply delay and jitter

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.

1.1.2.10.3.8.1.   *Reply delay and jitter for Modes A and C.* The reply delay and jitter for Modes A and C transactions shall be as provided in 1.1.1.7.10.

1.1.2.10.3.8.2.   *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 shall occur 128 plus or minus 0.25 microsecond after the sync phase reversal of the received P6. The jitter of the reply delay shall not exceed 0.08 microsecond, peak (99.9 percentile).

1.1.2.10.3.8.3.   *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 shall occur 128 plus or minus 0.5 microseconds after the leading edge of the P4 pulse of the interrogation. Jitter shall not exceed 0.1 microsecond, peak (99.9 percentile).*

Note.— A peak jitter of 0.1 microsecond is consistent with the jitter determined in 1.1.1.7.10.

1.1.2.10.3.9.   *Timers.* Duration and features of timers shall be as shown in Table 1-9. 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.

1.1.2.10.3.10.   *Inhibition of replies.* Replies to Mode A/C/S all-call and Mode S-only all-call interrogations shall always be inhibited when the aircraft 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.

1.1.2.10.3.10.1.   Aircraft shall provide means to determine the on-the-ground state automatically and provide that information to the transponder.

1.1.2.10.3.10.2.   Mode A/C replies shall be inhibited when the aircraft is on the ground to prevent interference when in 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.

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

1.1.2.10.5.   *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.

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

1.1.2.10.5.1.   *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 to minimize obstruction to their fields in the horizontal plane.

1.1.2.10.5.1.1. The horizontal distance between the top and bottom antennas shall 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 1.1.2.10.4.5.

1.1.2.10.5.2. *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 1.1.2.1 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 1.1.1.

Note. – Transponders equipped for diversity operation may optionally have the capability to evaluate additional characteristics of the received pulses of the interrogations in making a diversity channel selection. The transponder may as an option evaluate a complete Mode S interrogation simultaneously received on both channels to determine individually for each channel if the interrogation meets the requirements for Mode S interrogation acceptance as defined in 1.1.2.4.1.2.3.

1.1.2.10.5.2.1. 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.

1.1.2.10.5.2.2. 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.

1.1.2.10.5.2.3. 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.

1.1.2.10.5.2.4. *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 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 based on the simultaneous interrogation criteria or on the basis of the earlier time of arrival.

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

1.1.2.10.5.4.   *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 center 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.

1.1.2.10.6.   DATA PROCESSING AND INTERFACES

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

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

(a) the aircraft address;

(b) the maximum airspeed ; and

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

1.1.2.10.6.1.2.   Interfaces for fixed direct data

1.1.2.10.6.1.2.1.   Interfaces from the transponder *1.1.2.10.5.1.2* to the aircraft shall be designed such that the values of the fixed direct data become a function of the aircraft installation rather than of the transponder configuration.

Note.— The intent of this recommendation is to encourage an interface technique which permits transponder exchange without manipulation of the transponder itself for setting the fixed direct data.

1.1.2.10.6.1.3.   *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;

(b) the Mode A identity code;

(c) the on-the-ground condition;

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

(e) the SPI condition.

1.1.2.10.6.1.4.   Interfaces for variable direct data.

1.1.2.10.6.1.4.1.   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.

1.1.2.10.6.1.4.2.   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.

1.1.2.10.6.1.4.3.   For transponders of Level 2 and above, a means shall be provided, while on the ground or during flight, for the aircraft identification to be displayed to the pilot, and, when containing variable data (1.1.2.10.5.1.3 d)), to be 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.

1.1.2.10.6.1.4.4.   Interfaces shall be included to accept the pressure-altitude and on-the-ground coding.

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

1.1.2.10.6.2.   Indirect data

Note.— Indirect data are those which pass through the transponder in either direction but which do not affect the surveillance function.

If origins or destinations of indirect data are not within the transponder's enclosure, interfaces shall be used for the necessary connections.

1.1.2.10.6.2.1.   The function of interfaces

Note.— Indirect data interfaces for standard transactions serve interrogations which require a reply and the broadcast function. Indirect data interfaces for ELM serve that system and require buffering and protocol circuitry within the transponder. Interface ports can be separate for each direction and for each service or can be combined in any manner.

1.1.2.10.6.2.1.1.   *Uplink standard length transaction interface.* The uplink standard length transaction interface shall transfer all bits of accepted interrogations, (with the possible exception of the AP field), except for UF = 0, 11 or 16.

Note.— AP can also be transferred to aid in integrity implementation.

1.1.2.10.6.2.1.2.   *Downlink standard length transaction interface.* A transponder which transmits information originating in a peripheral device shall be able to receive bits or bit patterns for insertion at appropriate locations within the transmission. These locations shall not include those into which bit patterns generated internally by the transponder are inserted, nor the AP field of the reply. A transponder which transmits information using the Comm-B format shall have immediate access to requested data in the sense that the transponder shall respond to an interrogation with data requested by that interrogation.

Note.— This requirement may be met in two ways —

(a) the transponder may have provisions for internal data and protocol buffering; or

(b) the transponder may employ a "real time" interface which operates such that uplink data leave the transponder before the corresponding reply is generated and downlink data enter the transponder in time to be incorporated in the reply.

1.1.2.10.6.2.1.3.   Extended length message interface

Note.— The ELM interface extracts from, and enters into, the transponder the data exchanged between air and ground by means of the ELM protocol.

1.1.2.10.6.2.2.   Indirect data transaction rates

1.1.2.10.6.2.2.1.   *Standard length transactions.* A transponder equipped for information transfer to and from external devices shall be capable of processing the data of at least as many replies as determined for minimum reply rates in 1.10.3.7.2 and uplink data from interrogations being delivered at a rate of at least –

> *(a)* 50 long interrogations in any 1-second interval;
>
> *(b)* 18 long interrogations in a 100-millisecond interval;
>
> *(c)* long interrogations in a 25-millisecond interval; and
>
> *(d)* long interrogations in a 1.6-millisecond interval.

Note 1.— A transponder capable of reply rates higher than the minimum of 1.1.2.10.3.7.2 need not accept long interrogations after reaching the uplink data processing limits above.

Note 2.— The Mode S reply is the sole means of acknowledging receipt of the data content of a Mode S interrogation. Thus, if the transponder is capable of replying to an interrogation, the Mode S installation must be capable of accepting the data contained in that interrogation regardless of the timing between it and other accepted interrogations. Overlapping Mode S beams from several interrogators could lead to the requirement for considerable data processing and buffering. The minimum described here reduces data processing to a realistic level and the non-acceptance provision provides for notification to the interrogator that data will temporarily not be accepted.

1.1.2.10.6.2.2.2.   *Extended length transactions.* Level 3 and level 4) transponders shall be able to transfer data from at least four complete sixteen segment uplink ELMs in any four second interval. A level 5 transponder shall be able to transfer the data from at least four complete sixteen segment uplink ELMs in any one second interval and shall be capable of accepting at least two

complete sixteen segment uplink ELMs with the same II code in a 250 millisecond interval. A level 4 transponder shall be able to transmit at least one four-segment downlink ELM in any one second interval. A level 5 transponder shall be able to transmit at least one sixteen segment downlink ELM in any one second interval.

1.1.2.10.6.2.2.2.1.   Level 3 and level 4 transponders shall be able to accept at least two complete sixteen segment uplink ELMs in a 250 millisecond interval.

1.1.2.10.6.2.3.   Data formats for standard length transactions and required downlink aircraft parameters (DAPs)

1.1.2.10.6.2.3.1.   All level 2 and above transponders shall support the following registers –

   (a) the capability reports;

   (b) the aircraft identification protocol register 20 {HEX}; and

   (c) for ACAS-equipped aircraft, the active resolution advisory register 30 {HEX}.

1.1.2.10.6.2.3.2.   Where required, DAPs shall be supported by the registers listed in Table 1-12. The formats and minimum update rates of transponder registers shall be implemented consistently to ensure interoperability.

1.1.2.10.6.2.3.3.   The downlink standard length transaction interface shall deliver downlink aircraft parameters (DAPs) to the transponder which makes them available to the ground. Each DAP shall be packed into the Comm-B format ('MB' field) and can be extracted using either the ground-initiated Comm-B (GICB) protocol or using MSP downlink channel 3 via the dataflash application.

   Note.— The formats and update rates of each register and the dataflash application are specified in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

1.1.2.10.6.3.   *Integrity of data content transfer.* A transponder which employs data interfaces shall include sufficient protection to ensure error rates of less than one error in 103 messages and less than one undetected error in 107 112-bit transmissions in both directions between the antenna and each interface port.

1.1.2.10.6.4.   *Message cancellation.* The downlink standard length transaction interface and the extended length message interface shall include the capability to cancel a

message sent to the transponder for delivery to the ground, but whose delivery cycle has not been completed (that is, a closeout has not been accomplished by a ground interrogator).

Note.— One example of the need for this capability is to cancel a message if delivery is attempted when the aircraft is not within coverage of a Mode S ground station. The message must then be cancelled to prevent it from being read and interpreted as a current message when the aircraft re-enters Mode S airspace.

1.1.2.10.6.5.   *Air-directed messages.* The transfer of this type of message requires all the actions indicated in 1.1.2.10.5.4 plus the transfer to the transponder of the interrogator identifier of the site that is to receive the message.

1.1.2.11   ESSENTIAL SYSTEM CHARACTERISTICS OF THE GROUND INTERROGATOR

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

1.1.2.11.1.   *Interrogation repetition rates.* Mode S interrogators shall use the lowest practicable interrogation repetition rates for all interrogation modes.

Note.— Accurate azimuth data at low interrogation rates can be obtained with monopulse techniques.

1.1.2.11.1.1.   *All-call interrogation repetition rate.*

1.1.2.11.1.1.1.   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.

1.1.2.11.1.1.2.   *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.

1.1.2.11.1.2.   *Interrogation repetition rate to a single aircraft*

1.1.2.11.1.2.1.   *Interrogations requiring a reply.* Mode S interrogations requiring a reply shall not be transmitted to a single aircraft at intervals shorter than 400 microseconds.

1.1.2.11.1.2.2.   *Uplink ELM interrogations.* The minimum time between the beginning of successive Comm-C interrogations shall be 50 microseconds.

1.1.2.11.1.3.   Transmission rate for selective interrogations

1.1.2.11.1.3.1.   For all Mode S interrogators, the transmission rate for selective interrogations shall be –

   (a) less than 2 400 per second averaged over a 40-millisecond interval; and

   (b) less than 480 into any 3-degree sector averaged over a 1-second interval.

1.1.2.11.1.3.2.   Additionally, for a Mode S interrogator that has overlapping coverage with the side lobes of any other Mode S interrogator, the transmission rate for selective interrogations shall be –

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

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

Note.— Typical minimum distance to ensure side lobe separation between interrogators is 35 km.

1.1.2.11.2.   INTERROGATOR-EFFECTIVE RADIATED POWER

1.1.2.11.2.1.   The effective radiated power of all interrogation pulses shall be minimized as described in 1.1.1.8.2.

1.1.2.11.3.   *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.

1.1.2.11.3.1.   Spurious emission radiation

1.1.2.11.3.1.1.   CW radiation shall not exceed 76 dB below 1 watt.

1.1.2.11.4.   *Tolerances on transmitted signals.* In order that the signal-in-space be received by the transponder as described in 1.1.2.1, the tolerances on the transmitted signal shall be as summarized in Table 1-11.

1.1.2.11.5.   SPURIOUS RESPONSE

1.1.2.12   The response to signals not within the pass band shall be at least 60 dB below normal sensitivity.

1.1.2.12.1.   *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.

Note.— 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.

1.1.2.12.2.   MOBILE INTERROGATORS

1.1.2.12.2.1.   Mobile interrogators shall acquire, whenever possible, Mode S aircraft through the reception of squitters.

Note.— Passive squitter acquisition reduces channel loading and can be accomplished without the need for coordination.

TABLE FOR SCHEDULE 1

Table 1-1 Pulse shapes- Modes S and intermode interrogations

Pulse	Duration	Duration tolerance	(Rise time)		(Decay time)	
			Min.	Max.	Min.	Max.
P_1, P_2, P_3, P_5	0.8	±0.1	0.05	0.1	0.05	0.2
P_4 (short)	0.8	±0.1	0.05	0.1	0.05	0.2
P_4 (long)	1.6	±0.1	0.05	0.1	0.05	0.2
P_6 (short)	16.25	±0.25	0.05	0.1	0.05	0.2
P_6 (long)	30.25	±0.25	0.05	0.1	0.05	0.2
S_1	0.8	±0.1	0.05	0.1	0.05	0.2

Table 1-2. Pulse shapes — Mode S replies

Pulse duration	Duration tolerance	(Rise time)		(Decay time)	
		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

Table 1-3. Field definitions

Field		Format	
Designator	Function	UF	DF
AA	Address announced		11, 17, 18
AC	Altitude code		4, 20
AF	Application field		19
AP	Address/parity	All	0, 4, 5, 16, 20, 21, 24
AQ	Acquisition	0	
CA	Capability		11, 17
CC	Cross-link capability		0
CF	Control field		18
CL	Code label	11	
DF	Downlink format		All
DI	Designator identification	4, 5, 20, 21	
DR	Downlink request		4, 5, 20, 21
DS	Data selector	0	
FS	Flight status		4, 5, 20, 21
IC	Interrogator code	11	
ID	Identity		5, 21
KE	Control, ELM		24
MA	Message, Comm-A	20, 21	
MB	Message, Comm-B		20, 21
MC	Message, Comm-C	24	
MD	Message, Comm-D		24
ME	Message, extended squitter		17, 18
MU	Message, ACAS	16	
MV	Message, ACAS		16
NC	Number of C-segment	24	
ND	Number of D-segment		24
PC	Protocol	4, 5, 20, 21	
PI	Parity/interrogator identifier		11, 17, 18
PR	Probability of reply	11	
RC	Reply control	24	
RI	Reply information		0
RL	Reply length	0	
RR	Reply request	4, 5, 20, 21	
SD	Special designator	4, 5, 20, 21	
SL	Sensitivity Level (ACAS)		0, 16
UF	Uplink format	All	
UM	Utility message		4, 5, 20, 21
VS	Vertical status		0

Table 1-4. Subfield definitions

Designator	Function	Field
ACS	Altitude code subfield	ME
AIS	Aircraft identification subfield	MB
ATS	Altitude type subfield	MB
BDS 1	Comm-B data selector subfield 1	MB
BDS 2	Comm-B data selector subfield 2	MB
IDS	Identifier designator subfield	UM
IIS	Interrogator identifier subfield	SD
		UM
LOS	Lockout subfield	SD
LSS	Lockout surveillance subfield	SD
MBS	Multisite Comm-B subfield	SD
MES	Multisite ELM subfield	SD
RCS	Rate control subfield	SD
RRS	Reply request subfield	SD
RSS	Reservation status subfield	SD
SAS	Surface antenna subfield	SD
SCS	Squitter capability subfield	MB
SIC	Surveillance identifier capability	MB
SIS	Surveillance identifier subfield	SD
SRS	Segment request subfield	MC
SSS	Surveillance status subfield	ME
TAS	Transmission acknowledgement subfield	MD
TCS	Type control subfield	SD
TMS	Tactical message subfield	SD
TRS	Transmission rate subfield	MB

Table 1-5. Interrogation — reply protocol summary

Interrogation UF	Special conditions	Reply DF
0	RL (3.1.2.8.1.2) equals 0	0
	RL (3.1.2.8.1.2) equals 1	16
4	RR (3.1.2.6.1.2) less than 16	4
	RR (3.1.2.6.1.2) equal to or greater than 16	20
5	RR (3.1.2.6.1.2) less than 16	5
	RR (3.1.2.6.1.2) equal to or greater than 16	21
11	Transponder locked out to interrogator code, IC (3.1.2.5.2.1.2)	No reply
	Stochastic reply test fails (3.1.2.5.4)	No reply
	Otherwise	11
20	RR (3.1.2.6.1.2) less than 16	4
	RR (3.1.2.6.1.2) equal to or greater than 16	20
	AP contains broadcast address (3.1.2.4.1.2.3.1.3)	No reply
21	RR (3.1.2.6.1.2) less than 16	5
	RR (3.1.2.6.1.2) equal to or greater than 16	21
	AP contains broadcast address (3.1.2.4.1.2.3.1.3)	No reply
24	RC (3.1.2.7.1.1) equals 0 or 1	No reply
	RC (3.1.2.7.1.1) equals 2 or 3	24

Table 1-6. Register 10_{16}

Subfields of register 10_{16}	MB bits	Comm-B bits
Continuation flag	9	41
Overlay command capability	15	47
ACAS capability	16 and 37-40	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
Status of DTE sub-addresses 0 to 15	41-56	73-88

Table 1-7. Surface format broadcast without an automatic means of on-the-ground determination

	ADS-B Emitter Category Set "A"					
Coding	Meaning	Ground Speed		Airspeed		Ra dio 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		Ra dio 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"				
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		

Table 1-8: Character coding for transmission of aircraft identification by data link

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

Table 1-9: Timer characteristics

Timer				Duration	Tolerance	
Name	Number	Reference	Symbol	s	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
* As required						

Table 1-10. DAPS registers

Register	Name	Data content	Bits
40 (HEX)	Selected vertical intention	MCP/FCU selected altitude	1-13
		FMS selected altitude	14-26
		Barometric pressure setting minus 800 mb	27-39
		MCP/FCU mode bits	48-51
		Target altitude source bits	54-56
50 (HEX)	Track and turn report	Roll angle	1-11
		True track angle	12-23
		Ground speed	24-34
		Track angle rate	35-45
		True airspeed	46-56
60 (HEX)	Heading and speed report	Magnetic heading	1-12
		Indicated airspeed	13-23
		Mach	24-34
		Barometric altitude rate	35-45
		Inertial vertical velocity	46-56

Table 1-11: Transmitted signal tolerances

Function	Tolerance
Pulse duration P_1, P_2, P_3, P_4, P_5	±0.09 microsecond
Pulse duration P_6	±0.20 microsecond
Pulse duration $P_1 - P_3$	±0.18 microsecond
Pulse duration $P_1 - P_2$	±0.10 microsecond
Pulse duration $P_3 - P_4$	±0.04 microsecond
Pulse duration $P_1 - P_2$	±0.04 microsecond
Pulse duration P_2 — sync phase reversal	±0.04 microsecond
Pulse duration P_6 — sync phase reversal	±0.04 microsecond
Pulse duration P_5 — sync phase reversal	±0.05 microsecond
Pulse amplitude P_3	P_1 ±0.5 dB
Pulse amplitude P_4	P_3 ±0.5 dB
Pulse amplitude P_6	Equal to or greater than $P_3 - 0.25$ dB
Pulse rise times	0.05 microsecond minimum, 0.1 microsecond maximum
Pulse decay times	0.05 microsecond minimum, 0.2 microsecond maximum

FIGURES FOR SCHEDULE 1
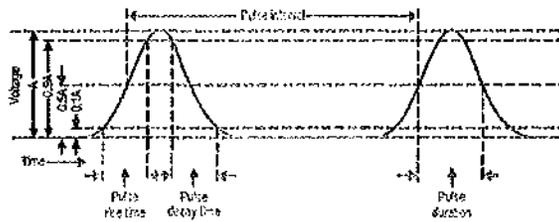
Definitions

Phase reversal. A 180-degree change in the phase of the radio frequency carrier.

Phase reversal duration. The time between the 10-degree and 170-degree points of a phase reversal.

Pulse amplitude A. The peak voltage amplitude of the pulse envelope.

Pulse decay time. The time between 0.9A and 0.1A on the trailing edge of the pulse envelope.

Pulse duration The time interval between 0.5A points on leading and trailing edges of the pulse envelope.

Pulse interval. The time interval between the 0.5A point on the leading edge of the first pulse and the 0.5A point on the leading edge of the second pulse.

Pulse rise time. The time between 0.1A and 0.9A on the leading edge of the pulse envelope.

Time intervals. The intervals are referenced to:

a) the 0.5A point on the leading edge of a pulse;

b) the 0.5A point on the trailing edge of a pulse; or

c) the 90-degree point of a phase reversal.

Transponder sensitivity and power reference point. The antenna end of the transmission line of the transponder.

Note.— *The 90-degree point of a phase reversal can be approximated by the minimum amplitude point on the envelope amplitude transient associated with the phase reversal and the phase reversal duration can be approximated by the time between the 0.8A points of the envelope amplitude transient.*
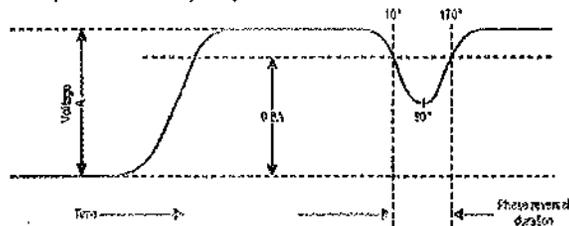
Figure 1-1. Definitions of secondary surveillance radar waveform shapes, intervals and the reference point for sensitivity and power
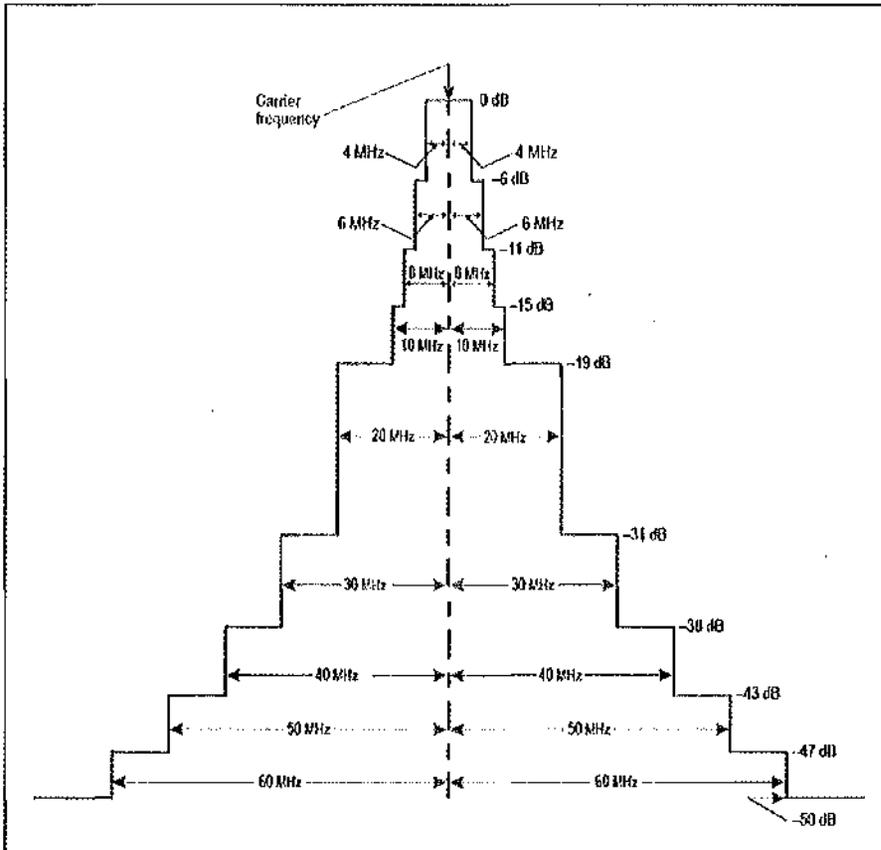
Figure 1-2. Required spectrum limits for interrogator transmitter
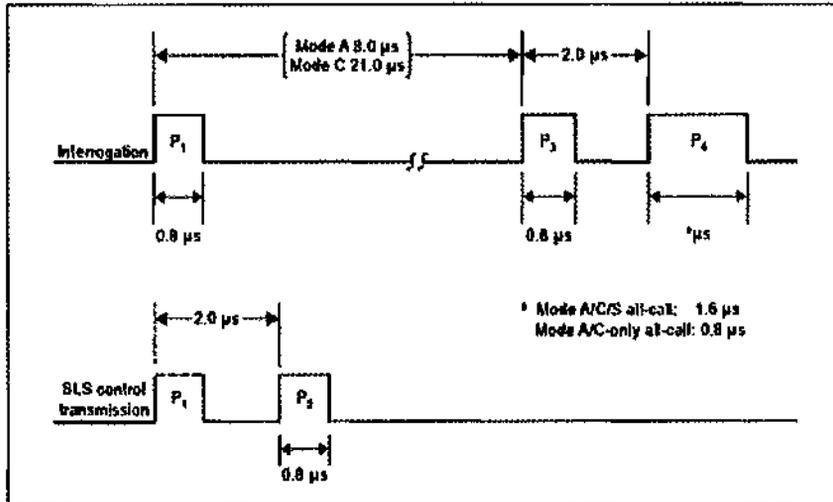
Figure 1-3. Intermode interrogation pulse sequence
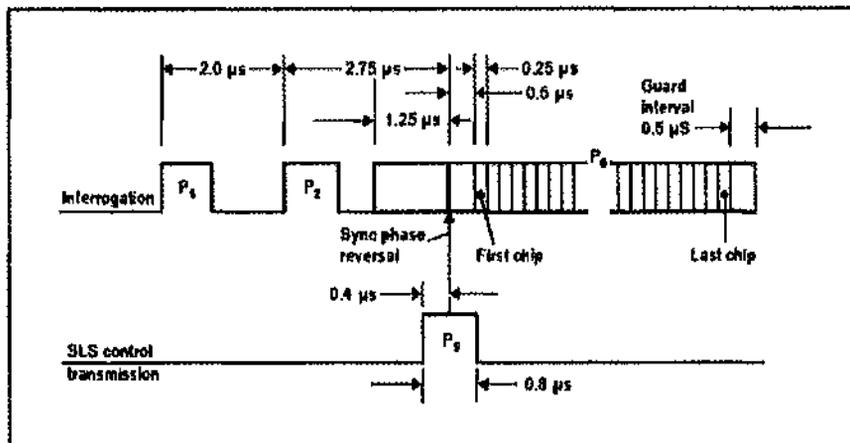
Figure 1-4. Mode S interrogation pulse sequence

Figure 1-5. Required spectrum limits for transponder transmitter

Note.— This figure shows the spectrum centred on the carrier frequency and will therefore shift in its entirety plus or minus 1 MHz along with the carrier frequency
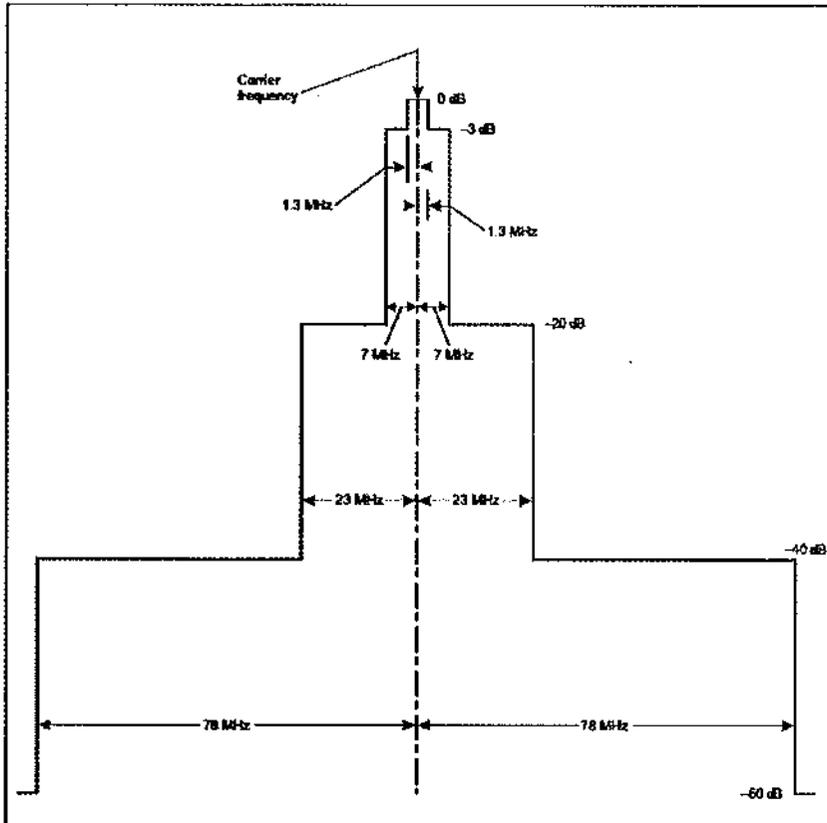
Figure 1-6. Mode S reply

Format No.	UF								Description
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					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 1-7. Summary of Mode S interrogation or uplink formats

Format No.	DF	Fields	
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, identity 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		... Military 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, identity 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.
2. P:24 denotes a 24-bit field reserved for parity information.
3. N denotes unassigned coding space with N available bits. These shall be coded as ZEROs for transmission.
4. 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.

5. 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.

6. The Data parity (DP) is used if it has been commanded by the OVC in accordance with paragraph 1.6.11.2.5.

Figure 1-8. Summary of Mode S reply or downlink formats

SSR automatic pressure-altitude transmission code
(Pulse position assignment)

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
-1 000 to -950		0	0	0	0	0	0	0	0	0	1	0
-950 to -850		0	0	0	0	0	0	0	0	1	1	0
-850 to -750		0	0	0	0	0	0	0	0	1	0	0
-750 to -650		0	0	0	0	0	0	0	1	1	0	0
-650 to -550		0	0	0	0	0	0	0	1	1	1	0
-550 to -450		0	0	0	0	0	0	0	1	0	1	0
-450 to -350		0	0	0	0	0	0	0	1	0	1	1
-350 to -250		0	0	0	0	0	0	0	1	0	0	1
-250 to -150		0	0	0	0	0	0	1	1	0	0	1
-150 to -50		0	0	0	0	0	0	1	1	0	1	1
-50 to 50		0	0	0	0	0	0	1	1	0	1	0
50 to 150		0	0	0	0	0	0	1	1	1	1	0
150 to 250		0	0	0	0	0	0	1	1	1	0	0
250 to 350		0	0	0	0	0	0	1	0	1	0	0
350 to 450		0	0	0	0	0	0	1	0	1	1	0
450 to 550		0	0	0	0	0	0	1	0	0	1	0
550 to 650		0	0	0	0	0	0	1	0	0	1	1
650 to 750		0	0	0	0	0	0	1	0	0	0	1
750 to 850		0	0	0	0	0	1	1	0	0	0	1
850 to 950		0	0	0	0	0	1	1	0	0	1	1
950 to 1 050		0	0	0	0	0	1	1	0	0	1	0
1 050 to 1 150		0	0	0	0	0	1	1	0	1	1	0
1 150 to 1 250		0	0	0	0	0	1	1	0	1	0	0
1 250 to 1 350		0	0	0	0	0	1	1	1	1	0	0
1 350 to 1 450		0	0	0	0	0	1	1	1	1	1	0
1 450 to 1 550		0	0	0	0	0	1	1	1	0	1	0
1 550 to 1 650		0	0	0	0	0	1	1	1	0	1	1
1 650 to 1 750		0	0	0	0	0	1	1	1	0	0	1
1 750 to 1 850		0	0	0	0	0	1	0	1	0	0	1
1 850 to 1 950		0	0	0	0	0	1	0	1	0	1	1
1 950 to 2 050		0	0	0	0	0	1	0	1	0	1	0
2 050 to 2 150		0	0	0	0	0	1	0	1	1	1	0
2 150 to 2 250		0	0	0	0	0	1	0	1	1	0	0
2 250 to 2 350		0	0	0	0	0	1	0	0	1	0	0
2 350 to 2 450		0	0	0	0	0	1	0	0	1	1	0
2 450 to 2 550		0	0	0	0	0	1	0	0	0	1	0
2 550 to 2 650		0	0	0	0	0	1	0	0	0	1	1
2 650 to 2 750		0	0	0	0	0	1	0	0	0	0	1

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_2	D_1	A_1	A_2	A_4	B_4	B_2	B_1	C_1	C_2	C_4
2 750 to 2 850	0	0	0	0	1	1	0	0	0	0	1
2 850 to 2 950	0	0	0	0	1	1	0	0	0	1	1
2 950 to 3 050	0	0	0	0	1	1	0	0	0	1	0
3 050 to 3 150	0	0	0	0	1	1	0	0	1	1	0
3 150 to 3 250	0	0	0	0	1	1	0	0	1	0	0
3 250 to 3 350	0	0	0	0	1	1	0	1	1	0	0
3 350 to 3 450	0	0	0	0	1	1	0	1	1	1	0
3 450 to 3 550	0	0	0	0	1	1	0	1	0	1	0
3 550 to 3 650	0	0	0	0	1	1	0	1	0	1	1
3 650 to 3 750	0	0	0	0	1	1	0	1	0	0	1
3 750 to 3 850	0	0	0	0	1	1	1	1	0	0	1
3 850 to 3 950	0	0	0	0	1	1	1	1	0	1	1
3 950 to 4 050	0	0	0	0	1	1	1	1	0	1	0
4 050 to 4 150	0	0	0	0	1	1	1	1	1	1	0
4 150 to 4 250	0	0	0	0	1	1	1	1	1	0	0
4 250 to 4 350	0	0	0	0	1	1	1	0	1	0	0
4 350 to 4 450	0	0	0	0	1	1	1	0	1	1	0
4 450 to 4 550	0	0	0	0	1	1	1	0	0	1	0
4 550 to 4 650	0	0	0	0	1	1	1	0	0	1	1
4 650 to 4 750	0	0	0	0	1	1	1	0	0	0	1
4 750 to 4 850	0	0	0	0	1	0	1	0	0	0	1
4 850 to 4 950	0	0	0	0	1	0	1	0	0	1	1
4 950 to 5 050	0	0	0	0	1	0	1	0	0	1	0
5 050 to 5 150	0	0	0	0	1	0	1	0	1	1	0
5 150 to 5 250	0	0	0	0	1	0	1	0	1	0	0
5 250 to 5 350	0	0	0	0	1	0	1	1	1	0	0
5 350 to 5 450	0	0	0	0	1	0	1	1	1	1	0
5 450 to 5 550	0	0	0	0	1	0	1	1	0	1	0
5 550 to 5 650	0	0	0	0	1	0	1	1	0	1	1
5 650 to 5 750	0	0	0	0	1	0	1	1	0	0	1
5 750 to 5 850	0	0	0	0	1	0	0	1	0	0	1
5 850 to 5 950	0	0	0	0	1	0	0	1	0	1	1
5 950 to 6 050	0	0	0	0	1	0	0	1	0	1	0
6 050 to 6 150	0	0	0	0	1	0	0	1	1	1	0
6 150 to 6 250	0	0	0	0	1	0	0	1	1	0	0
6 250 to 6 350	0	0	0	0	1	0	0	0	1	0	0
6 350 to 6 450	0	0	0	0	1	0	0	0	1	1	0
6 450 to 6 550	0	0	0	0	1	0	0	0	0	1	0
6 550 to 6 650	0	0	0	0	1	0	0	0	0	1	1
6 650 to 6 750	0	0	0	0	1	0	0	0	0	0	1
6 750 to 6 850	0	0	0	1	1	0	0	0	0	0	1
6 850 to 6 950	0	0	0	1	1	0	0	0	0	1	1
6 950 to 7 050	0	0	0	1	1	0	0	0	0	1	0
7 050 to 7 150	0	0	0	1	1	0	0	0	1	1	0
7 150 to 7 250	0	0	0	1	1	0	0	0	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
7 250 to 7 350		0	0	0	1	1	0	0	1	1	0	0
7 350 to 7 450		0	0	0	1	1	0	0	1	1	1	0
7 450 to 7 550		0	0	0	1	1	0	0	1	0	1	0
7 550 to 7 650		0	0	0	1	1	0	0	1	0	1	1
7 650 to 7 750		0	0	0	1	1	0	0	1	0	0	1
7 750 to 7 850		0	0	0	1	1	0	1	1	0	0	1
7 850 to 7 950		0	0	0	1	1	0	1	1	0	1	1
7 950 to 8 050		0	0	0	1	1	0	1	1	0	1	0
8 050 to 8 150		0	0	0	1	1	0	1	1	1	1	0
8 150 to 8 250		0	0	0	1	1	0	1	1	1	0	0
8 250 to 8 350		0	0	0	1	1	0	1	0	1	0	0
8 350 to 8 450		0	0	0	1	1	0	1	0	1	1	0
8 450 to 8 550		0	0	0	1	1	0	1	0	0	1	0
8 550 to 8 650		0	0	0	1	1	0	1	0	0	1	1
8 650 to 8 750		0	0	0	1	1	0	1	0	0	0	1
8 750 to 8 850		0	0	0	1	1	1	1	0	0	0	1
8 850 to 8 950		0	0	0	1	1	1	1	0	0	1	1
8 950 to 9 050		0	0	0	1	1	1	1	0	0	1	0
9 050 to 9 150		0	0	0	1	1	1	1	0	1	1	0
9 150 to 9 250		0	0	0	1	1	1	1	0	1	0	0
9 250 to 9 350		0	0	0	1	1	1	1	1	1	0	0
9 350 to 9 450		0	0	0	1	1	1	1	1	1	1	0
9 450 to 9 550		0	0	0	1	1	1	1	1	0	1	0
9 550 to 9 650		0	0	0	1	1	1	1	1	0	1	1
9 650 to 9 750		0	0	0	1	1	1	1	1	0	0	1
9 750 to 9 850		0	0	0	1	1	1	0	1	0	0	1
9 850 to 9 950		0	0	0	1	1	1	0	1	0	1	1
9 950 to 10 050		0	0	0	1	1	1	0	1	0	1	0
10 050 to 10 150		0	0	0	1	1	1	0	1	1	1	0
10 150 to 10 250		0	0	0	1	1	1	0	1	1	0	0
10 250 to 10 350		0	0	0	1	1	1	0	0	1	0	0
10 350 to 10 450		0	0	0	1	1	1	0	0	1	1	0
10 450 to 10 550		0	0	0	1	1	1	0	0	0	1	0
10 550 to 10 650		0	0	0	1	1	1	0	0	0	1	1
10 650 to 10 750		0	0	0	1	1	1	0	0	0	0	1
10 750 to 10 850		0	0	0	1	0	1	0	0	0	0	1
10 850 to 10 950		0	0	0	1	0	1	0	0	0	1	1
10 950 to 11 050		0	0	0	1	0	1	0	0	0	1	0
11 050 to 11 150		0	0	0	1	0	1	0	0	1	1	0
11 150 to 11 250		0	0	0	1	0	1	0	0	1	0	0
11 250 to 11 350		0	0	0	1	0	1	0	1	1	0	0
11 350 to 11 450		0	0	0	1	0	1	0	1	1	1	0
11 450 to 11 550		0	0	0	1	0	1	0	1	0	1	0
11 550 to 11 650		0	0	0	1	0	1	0	1	0	1	1
11 650 to 11 750		0	0	0	1	0	1	0	1	0	0	1

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)			D_1	D_2	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
16 250	to	16 350	0	0	1	1	0	0	1	0	1	0	0
16 350	to	16 450	0	0	1	1	0	0	1	0	1	1	0
16 450	to	16 550	0	0	1	1	0	0	1	0	0	1	0
16 550	to	16 650	0	0	1	1	0	0	1	0	0	1	1
16 650	to	16 750	0	0	1	1	0	0	1	0	0	0	1
16 750	to	16 850	0	0	1	1	0	1	1	0	0	0	1
16 850	to	16 950	0	0	1	1	0	1	1	0	0	1	1
16 950	to	17 050	0	0	1	1	0	1	1	0	0	1	0
17 050	to	17 150	0	0	1	1	0	1	1	0	1	1	0
17 150	to	17 250	0	0	1	1	0	1	1	0	1	0	0
17 250	to	17 350	0	0	1	1	0	1	1	1	1	0	0
17 350	to	17 450	0	0	1	1	0	1	1	1	1	1	0
17 450	to	17 550	0	0	1	1	0	1	1	1	0	1	0
17 550	to	17 650	0	0	1	1	0	1	1	1	0	1	1
17 650	to	17 750	0	0	1	1	0	1	1	1	0	0	1
17 750	to	17 850	0	0	1	1	0	1	0	1	0	0	1
17 850	to	17 950	0	0	1	1	0	1	0	1	0	1	1
17 950	to	18 050	0	0	1	1	0	1	0	1	0	1	0
18 050	to	18 150	0	0	1	1	0	1	0	1	1	1	0
18 150	to	18 250	0	0	1	1	0	1	0	1	1	0	0
18 250	to	18 350	0	0	1	1	0	1	0	0	1	0	0
18 350	to	18 450	0	0	1	1	0	1	0	0	1	1	0
18 450	to	18 550	0	0	1	1	0	1	0	0	0	1	0
18 550	to	18 650	0	0	1	1	0	1	0	0	0	1	1
18 650	to	18 750	0	0	1	1	0	1	0	0	0	0	1
18 750	to	18 850	0	0	1	1	1	1	0	0	0	0	1
18 850	to	18 950	0	0	1	1	1	1	0	0	0	1	1
18 950	to	19 050	0	0	1	1	1	1	0	0	0	1	0
19 050	to	19 150	0	0	1	1	1	1	0	0	1	1	0
19 150	to	19 250	0	0	1	1	1	1	0	0	1	0	0
19 250	to	19 350	0	0	1	1	1	1	0	1	1	0	0
19 350	to	19 450	0	0	1	1	1	1	0	1	1	1	0
19 450	to	19 550	0	0	1	1	1	1	0	1	0	1	0
19 550	to	19 650	0	0	1	1	1	1	0	1	0	1	1
19 650	to	19 750	0	0	1	1	1	1	0	1	0	0	1
19 750	to	19 850	0	0	1	1	1	1	1	1	0	0	1
19 850	to	19 950	0	0	1	1	1	1	1	1	0	1	1
19 950	to	20 050	0	0	1	1	1	1	1	1	0	1	0
20 050	to	20 150	0	0	1	1	1	1	1	1	1	1	0
20 150	to	20 250	0	0	1	1	1	1	1	1	1	0	0
20 250	to	20 350	0	0	1	1	1	1	1	0	1	0	0
20 350	to	20 450	0	0	1	1	1	1	1	0	1	1	0
20 450	to	20 550	0	0	1	1	1	1	1	0	0	1	0
20 550	to	20 650	0	0	1	1	1	1	1	0	0	1	1
20 650	to	20 750	0	0	1	1	1	1	1	0	0	0	1

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)			D_1	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
20 750	to	20 850	0	0	1	1	1	0	1	0	0	0	1
20 850	to	20 950	0	0	1	1	1	0	1	0	0	1	1
20 950	to	21 050	0	0	1	1	1	0	1	0	0	1	0
21 050	to	21 150	0	0	1	1	1	0	1	0	1	1	0
21 150	to	21 250	0	0	1	1	1	0	1	0	1	0	0
21 250	to	21 350	0	0	1	1	1	0	1	1	1	0	0
21 350	to	21 450	0	0	1	1	1	0	1	1	1	1	0
21 450	to	21 550	0	0	1	1	1	0	1	1	0	1	0
21 550	to	21 650	0	0	1	1	1	0	1	1	0	1	1
21 650	to	21 750	0	0	1	1	1	0	1	1	0	0	1
21 750	to	21 850	0	0	1	1	1	0	0	1	0	0	1
21 850	to	21 950	0	0	1	1	1	0	0	1	0	1	1
21 950	to	22 050	0	0	1	1	1	0	0	1	0	1	0
22 050	to	22 150	0	0	1	1	1	0	0	1	1	1	0
22 150	to	22 250	0	0	1	1	1	0	0	1	1	0	0
22 250	to	22 350	0	0	1	1	1	0	0	0	1	0	0
22 350	to	22 450	0	0	1	1	1	0	0	0	1	1	0
22 450	to	22 550	0	0	1	1	1	0	0	0	0	1	0
22 550	to	22 650	0	0	1	1	1	0	0	0	0	1	1
22 650	to	22 750	0	0	1	1	1	0	0	0	0	0	1
22 750	to	22 850	0	0	1	0	1	0	0	0	0	0	1
22 850	to	22 950	0	0	1	0	1	0	0	0	0	1	1
22 950	to	23 050	0	0	1	0	1	0	0	0	0	1	0
23 050	to	23 150	0	0	1	0	1	0	0	0	1	1	0
23 150	to	23 250	0	0	1	0	1	0	0	0	1	0	0
23 250	to	23 350	0	0	1	0	1	0	0	1	1	0	0
23 350	to	23 450	0	0	1	0	1	0	0	1	1	1	0
23 450	to	23 550	0	0	1	0	1	0	0	1	0	1	0
23 550	to	23 650	0	0	1	0	1	0	0	1	0	1	1
23 650	to	23 750	0	0	1	0	1	0	0	1	0	0	1
23 750	to	23 850	0	0	1	0	1	0	1	1	0	0	1
23 850	to	23 950	0	0	1	0	1	0	1	1	0	1	1
23 950	to	24 050	0	0	1	0	1	0	1	1	0	1	0
24 050	to	24 150	0	0	1	0	1	0	1	1	1	1	0
24 150	to	24 250	0	0	1	0	1	0	1	1	1	0	0
24 250	to	24 350	0	0	1	0	1	0	1	0	1	0	0
24 350	to	24 450	0	0	1	0	1	0	1	0	1	1	0
24 450	to	24 550	0	0	1	0	1	0	1	0	0	1	0
24 550	to	24 650	0	0	1	0	1	0	1	0	0	1	1
24 650	to	24 750	0	0	1	0	1	0	1	0	0	0	1
24 750	to	24 850	0	0	1	0	1	1	1	0	0	0	1
24 850	to	24 950	0	0	1	0	1	1	1	0	0	1	1
24 950	to	25 050	0	0	1	0	1	1	1	0	0	1	0
25 050	to	25 150	0	0	1	0	1	1	1	0	1	1	0
25 150	to	25 250	0	0	1	0	1	1	1	0	1	0	0

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
25 250	to	25 350	0	0	1	0	1	1	1	1	1	0	0
25 350	to	25 450	0	0	1	0	1	1	1	1	1	1	0
25 450	to	25 550	0	0	1	0	1	1	1	1	0	1	0
25 550	to	25 650	0	0	1	0	1	1	1	1	0	1	1
25 650	to	25 750	0	0	1	0	1	1	1	1	0	0	1
25 750	to	25 850	0	0	1	0	1	1	0	1	0	0	1
25 850	to	25 950	0	0	1	0	1	1	0	1	0	1	1
25 950	to	26 050	0	0	1	0	1	1	0	1	0	1	0
26 050	to	26 150	0	0	1	0	1	1	0	1	1	1	0
26 150	to	26 250	0	0	1	0	1	1	0	1	1	0	0
26 250	to	26 350	0	0	1	0	1	1	0	0	1	0	0
26 350	to	26 450	0	0	1	0	1	1	0	0	1	1	0
26 450	to	26 550	0	0	1	0	1	1	0	0	0	1	0
26 550	to	26 650	0	0	1	0	1	1	0	0	0	1	1
26 650	to	26 750	0	0	1	0	1	1	0	0	0	0	1
26 750	to	26 850	0	0	1	0	0	1	0	0	0	0	1
26 850	to	26 950	0	0	1	0	0	1	0	0	0	1	1
26 950	to	27 050	0	0	1	0	0	1	0	0	0	1	0
27 050	to	27 150	0	0	1	0	0	1	0	0	1	1	0
27 150	to	27 250	0	0	1	0	0	1	0	0	1	0	0
27 250	to	27 350	0	0	1	0	0	1	0	1	1	0	0
27 350	to	27 450	0	0	1	0	0	1	0	1	1	1	0
27 450	to	27 550	0	0	1	0	0	1	0	1	0	1	0
27 550	to	27 650	0	0	1	0	0	1	0	1	0	1	1
27 650	to	27 750	0	0	1	0	0	1	0	1	0	0	1
27 750	to	27 850	0	0	1	0	0	1	1	1	0	0	1
27 850	to	27 950	0	0	1	0	0	1	1	1	0	1	1
27 950	to	28 050	0	0	1	0	0	1	1	1	0	1	0
28 050	to	28 150	0	0	1	0	0	1	1	1	1	1	0
28 150	to	28 250	0	0	1	0	0	1	1	1	1	0	0
28 250	to	28 350	0	0	1	0	0	1	1	0	1	0	0
28 350	to	28 450	0	0	1	0	0	1	1	0	1	1	0
28 450	to	28 550	0	0	1	0	0	1	1	0	0	1	0
28 550	to	28 650	0	0	1	0	0	1	1	0	0	1	1
28 650	to	28 750	0	0	1	0	0	1	1	0	0	0	1
28 750	to	28 850	0	0	1	0	0	0	1	0	0	0	1
28 850	to	28 950	0	0	1	0	0	0	1	0	0	1	1
28 950	to	29 050	0	0	1	0	0	0	1	0	0	1	0
29 050	to	29 150	0	0	1	0	0	0	1	0	1	1	0
29 150	to	29 250	0	0	1	0	0	0	1	0	1	0	0
29 250	to	29 350	0	0	1	0	0	0	1	1	1	0	0
29 350	to	29 450	0	0	1	0	0	0	1	1	1	1	0
29 450	to	29 550	0	0	1	0	0	0	1	1	0	1	0
29 550	to	29 650	0	0	1	0	0	0	1	1	0	1	1
29 650	to	29 750	0	0	1	0	0	0	1	1	0	0	1

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)			D_2	D_1	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
29 750	to	29 850	0	0	1	0	0	0	0	1	0	0	1
29 850	to	29 950	0	0	1	0	0	0	0	1	0	1	1
29 950	to	30 050	0	0	1	0	0	0	0	1	0	1	0
30 050	to	30 150	0	0	1	0	0	0	0	1	1	1	0
30 150	to	30 250	0	0	1	0	0	0	0	1	1	0	0
30 250	to	30 350	0	0	1	0	0	0	0	0	1	0	0
30 350	to	30 450	0	0	1	0	0	0	0	0	1	1	0
30 450	to	30 550	0	0	1	0	0	0	0	0	0	1	0
30 550	to	30 650	0	0	1	0	0	0	0	0	0	1	1
30 650	to	30 750	0	0	1	0	0	0	0	0	0	0	1
30 750	to	30 850	0	1	1	0	0	0	0	0	0	0	1
30 850	to	30 950	0	1	1	0	0	0	0	0	0	1	1
30 950	to	31 050	0	1	1	0	0	0	0	0	0	1	0
31 050	to	31 150	0	1	1	0	0	0	0	0	1	1	0
31 150	to	31 250	0	1	1	0	0	0	0	0	1	0	0
31 250	to	31 350	0	1	1	0	0	0	0	1	1	0	0
31 350	to	31 450	0	1	1	0	0	0	0	1	1	1	0
31 450	to	31 550	0	1	1	0	0	0	0	1	0	1	0
31 550	to	31 650	0	1	1	0	0	0	0	1	0	1	1
31 650	to	31 750	0	1	1	0	0	0	0	1	0	0	1
31 750	to	31 850	0	1	1	0	0	0	1	1	0	0	1
31 850	to	31 950	0	1	1	0	0	0	1	1	0	1	1
31 950	to	32 050	0	1	1	0	0	0	1	1	0	1	0
32 050	to	32 150	0	1	1	0	0	0	1	1	1	1	0
32 150	to	32 250	0	1	1	0	0	0	1	1	1	0	0
32 250	to	32 350	0	1	1	0	0	0	1	0	1	0	0
32 350	to	32 450	0	1	1	0	0	0	1	0	1	1	0
32 450	to	32 550	0	1	1	0	0	0	1	0	0	1	0
32 550	to	32 650	0	1	1	0	0	0	1	0	0	1	1
32 650	to	32 750	0	1	1	0	0	0	1	0	0	0	1
32 750	to	32 850	0	1	1	0	0	1	1	0	0	0	1
32 850	to	32 950	0	1	1	0	0	1	1	0	0	1	1
32 950	to	33 050	0	1	1	0	0	1	1	0	0	1	0
33 050	to	33 150	0	1	1	0	0	1	1	0	1	1	0
33 150	to	33 250	0	1	1	0	0	1	1	0	1	0	0
33 250	to	33 350	0	1	1	0	0	1	1	1	1	0	0
33 350	to	33 450	0	1	1	0	0	1	1	1	1	1	0
33 450	to	33 550	0	1	1	0	0	1	1	1	0	1	0
33 550	to	33 650	0	1	1	0	0	1	1	1	0	1	1
33 650	to	33 750	0	1	1	0	0	1	1	1	0	0	1
33 750	to	33 850	0	1	1	0	0	1	0	1	0	0	1
33 850	to	33 950	0	1	1	0	0	1	0	1	0	1	1
33 950	to	34 050	0	1	1	0	0	1	0	1	0	1	0
34 050	to	34 150	0	1	1	0	0	1	0	1	1	1	0
34 150	to	34 250	0	1	1	0	0	1	0	1	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (feet)		D_1	D_4	A_1	A_3	A_4	B_1	B_2	B_4	C_1	C_2	C_4
34 250 to 34 350		0	1	1	0	0	1	0	0	1	0	0
34 350 to 34 450		0	1	1	0	0	1	0	0	1	1	0
34 450 to 34 550		0	1	1	0	0	1	0	0	0	1	0
34 550 to 34 650		0	1	1	0	0	1	0	0	0	1	1
34 650 to 34 750		0	1	1	0	0	1	0	0	0	0	1
34 750 to 34 850		0	1	1	0	1	1	0	0	0	0	1
34 850 to 34 950		0	1	1	0	1	1	0	0	0	1	1
34 950 to 35 050		0	1	1	0	1	1	0	0	0	1	0
35 050 to 35 150		0	1	1	0	1	1	0	0	1	1	0
35 150 to 35 250		0	1	1	0	1	1	0	0	1	0	0
35 250 to 35 350		0	1	1	0	1	1	0	1	1	0	0
35 350 to 35 450		0	1	1	0	1	1	0	1	1	1	0
35 450 to 35 550		0	1	1	0	1	1	0	1	0	1	0
35 550 to 35 650		0	1	1	0	1	1	0	1	0	1	1
35 650 to 35 750		0	1	1	0	1	1	0	1	0	0	1
35 750 to 35 850		0	1	1	0	1	1	1	1	0	0	1
35 850 to 35 950		0	1	1	0	1	1	1	1	0	1	1
35 950 to 36 050		0	1	1	0	1	1	1	1	0	1	0
36 050 to 36 150		0	1	1	0	1	1	1	1	1	1	0
36 150 to 36 250		0	1	1	0	1	1	1	1	1	0	0
36 250 to 36 350		0	1	1	0	1	1	1	0	1	0	0
36 350 to 36 450		0	1	1	0	1	1	1	0	1	1	0
36 450 to 36 550		0	1	1	0	1	1	1	0	0	1	0
36 550 to 36 650		0	1	1	0	1	1	1	0	0	1	1
36 650 to 36 750		0	1	1	0	1	1	1	0	0	0	1
36 750 to 36 850		0	1	1	0	1	0	1	0	0	0	1
36 850 to 36 950		0	1	1	0	1	0	1	0	0	1	1
36 950 to 37 050		0	1	1	0	1	0	1	0	0	1	0
37 050 to 37 150		0	1	1	0	1	0	1	0	1	1	0
37 150 to 37 250		0	1	1	0	1	0	1	0	1	0	0
37 250 to 37 350		0	1	1	0	1	0	1	1	1	0	0
37 350 to 37 450		0	1	1	0	1	0	1	1	1	1	0
37 450 to 37 550		0	1	1	0	1	0	1	1	0	1	0
37 550 to 37 650		0	1	1	0	1	0	1	1	0	1	1
37 650 to 37 750		0	1	1	0	1	0	1	1	0	0	1
37 750 to 37 850		0	1	1	0	1	0	0	1	0	0	1
37 850 to 37 950		0	1	1	0	1	0	0	1	0	1	1
37 950 to 38 050		0	1	1	0	1	0	0	1	0	1	0
38 050 to 38 150		0	1	1	0	1	0	0	1	1	1	0
38 150 to 38 250		0	1	1	0	1	0	0	1	1	0	0
38 250 to 38 350		0	1	1	0	1	0	0	0	1	0	0
38 350 to 38 450		0	1	1	0	1	0	0	0	1	1	0
38 450 to 38 550		0	1	1	0	1	0	0	0	0	1	0
38 550 to 38 650		0	1	1	0	1	0	0	0	0	1	1
38 650 to 38 750		0	1	1	0	1	0	0	0	0	0	1

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)			D_1	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
38 750	to	38 850	0	1	1	1	1	0	0	0	0	0	1
38 850	to	38 950	0	1	1	1	1	0	0	0	0	1	1
38 950	to	39 050	0	1	1	1	1	0	0	0	0	1	0
39 050	to	39 150	0	1	1	1	1	0	0	0	1	1	0
39 150	to	39 250	0	1	1	1	1	0	0	0	1	0	0
39 250	to	39 350	0	1	1	1	1	0	0	1	1	0	0
39 350	to	39 450	0	1	1	1	1	0	0	1	1	1	0
39 450	to	39 550	0	1	1	1	1	0	0	1	0	1	0
39 550	to	39 650	0	1	1	1	1	0	0	1	0	1	1
39 650	to	39 750	0	1	1	1	1	0	0	1	0	0	1
39 750	to	39 850	0	1	1	1	1	0	1	1	0	0	1
39 850	to	39 950	0	1	1	1	1	0	1	1	0	1	1
39 950	to	40 050	0	1	1	1	1	0	1	1	0	1	0
40 050	to	40 150	0	1	1	1	1	0	1	1	1	1	0
40 150	to	40 250	0	1	1	1	1	0	1	1	1	0	0
40 250	to	40 350	0	1	1	1	1	0	1	0	1	0	0
40 350	to	40 450	0	1	1	1	1	0	1	0	1	1	0
40 450	to	40 550	0	1	1	1	1	0	1	0	0	1	0
40 550	to	40 650	0	1	1	1	1	0	1	0	0	1	1
40 650	to	40 750	0	1	1	1	1	0	1	0	0	0	1
40 750	to	40 850	0	1	1	1	1	1	1	0	0	0	1
40 850	to	40 950	0	1	1	1	1	1	1	0	0	1	1
40 950	to	41 050	0	1	1	1	1	1	1	0	0	1	0
41 050	to	41 150	0	1	1	1	1	1	1	0	1	1	0
41 150	to	41 250	0	1	1	1	1	1	1	0	1	0	0
41 250	to	41 350	0	1	1	1	1	1	1	1	1	0	0
41 350	to	41 450	0	1	1	1	1	1	1	1	1	1	0
41 450	to	41 550	0	1	1	1	1	1	1	1	0	1	0
41 550	to	41 650	0	1	1	1	1	1	1	1	0	1	1
41 650	to	41 750	0	1	1	1	1	1	1	1	0	0	1
41 750	to	41 850	0	1	1	1	1	1	0	1	0	0	1
41 850	to	41 950	0	1	1	1	1	1	0	1	0	1	1
41 950	to	42 050	0	1	1	1	1	1	0	1	0	1	0
42 050	to	42 150	0	1	1	1	1	1	0	1	1	1	0
42 150	to	42 250	0	1	1	1	1	1	0	1	1	0	0
42 250	to	42 350	0	1	1	1	1	1	0	0	1	0	0
42 350	to	42 450	0	1	1	1	1	1	0	0	1	1	0
42 450	to	42 550	0	1	1	1	1	1	0	0	0	1	0
42 550	to	42 650	0	1	1	1	1	1	0	0	0	1	1
42 650	to	42 750	0	1	1	1	1	1	0	0	0	0	1
42 750	to	42 850	0	1	1	1	0	1	0	0	0	0	1
42 850	to	42 950	0	1	1	1	0	1	0	0	0	1	1
42 950	to	43 050	0	1	1	1	0	1	0	0	0	1	0
43 050	to	43 150	0	1	1	1	0	1	0	0	1	1	0
43 150	to	43 250	0	1	1	1	0	1	0	0	1	0	0

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_2	D_1	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
43 250 to 43 350	0	1	1	1	0	1	0	1	1	0	0
43 350 to 43 450	0	1	1	1	0	1	0	1	1	1	0
43 450 to 43 550	0	1	1	1	0	1	0	1	0	1	0
43 550 to 43 650	0	1	1	1	0	1	0	1	0	1	1
43 650 to 43 750	0	1	1	1	0	1	0	1	0	0	1
43 750 to 43 850	0	1	1	1	0	1	1	1	0	0	1
43 850 to 43 950	0	1	1	1	0	1	1	1	0	1	1
43 950 to 44 050	0	1	1	1	0	1	1	1	0	1	0
44 050 to 44 150	0	1	1	1	0	1	1	1	1	1	0
44 150 to 44 250	0	1	1	1	0	1	1	1	1	0	0
44 250 to 44 350	0	1	1	1	0	1	1	0	1	0	0
44 350 to 44 450	0	1	1	1	0	1	1	0	1	1	0
44 450 to 44 550	0	1	1	1	0	1	1	0	0	1	0
44 550 to 44 650	0	1	1	1	0	1	1	0	0	1	1
44 650 to 44 750	0	1	1	1	0	1	1	0	0	0	1
44 750 to 44 850	0	1	1	1	0	0	1	0	0	0	1
44 850 to 44 950	0	1	1	1	0	0	1	0	0	1	1
44 950 to 45 050	0	1	1	1	0	0	1	0	0	1	0
45 050 to 45 150	0	1	1	1	0	0	1	0	1	1	0
45 150 to 45 250	0	1	1	1	0	0	1	0	1	0	0
45 250 to 45 350	0	1	1	1	0	0	1	1	1	0	0
45 350 to 45 450	0	1	1	1	0	0	1	1	1	1	0
45 450 to 45 550	0	1	1	1	0	0	1	1	0	1	0
45 550 to 45 650	0	1	1	1	0	0	1	1	0	1	1
45 650 to 45 750	0	1	1	1	0	0	1	1	0	0	1
45 750 to 45 850	0	1	1	1	0	0	0	1	0	0	1
45 850 to 45 950	0	1	1	1	0	0	0	1	0	1	1
45 950 to 46 050	0	1	1	1	0	0	0	1	0	1	0
46 050 to 46 150	0	1	1	1	0	0	0	1	1	1	0
46 150 to 46 250	0	1	1	1	0	0	0	1	1	0	0
46 250 to 46 350	0	1	1	1	0	0	0	0	1	0	0
46 350 to 46 450	0	1	1	1	0	0	0	0	1	1	0
46 450 to 46 550	0	1	1	1	0	0	0	0	0	1	0
46 550 to 46 650	0	1	1	1	0	0	0	0	0	1	1
46 650 to 46 750	0	1	1	1	0	0	0	0	0	0	1
46 750 to 46 850	0	1	0	1	0	0	0	0	0	0	1
46 850 to 46 950	0	1	0	1	0	0	0	0	0	1	1
46 950 to 47 050	0	1	0	1	0	0	0	0	0	1	0
47 050 to 47 150	0	1	0	1	0	0	0	0	1	1	0
47 150 to 47 250	0	1	0	1	0	0	0	0	1	0	0
47 250 to 47 350	0	1	0	1	0	0	0	1	1	0	0
47 350 to 47 450	0	1	0	1	0	0	0	1	1	1	0
47 450 to 47 550	0	1	0	1	0	0	0	1	0	1	0
47 550 to 47 650	0	1	0	1	0	0	0	1	0	1	1
47 650 to 47 750	0	1	0	1	0	0	0	1	0	0	1

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_f
47 750 to 47 850		0	1	0	1	0	0	1	1	0	0	1
47 850 to 47 950		0	1	0	1	0	0	1	1	0	1	1
47 950 to 48 050		0	1	0	1	0	0	1	1	0	1	0
48 050 to 48 150		0	1	0	1	0	0	1	1	1	1	0
48 150 to 48 250		0	1	0	1	0	0	1	1	1	0	0
48 250 to 48 350		0	1	0	1	0	0	1	0	1	0	0
48 350 to 48 450		0	1	0	1	0	0	1	0	1	1	0
48 450 to 48 550		0	1	0	1	0	0	1	0	0	1	0
48 550 to 48 650		0	1	0	1	0	0	1	0	0	1	1
48 650 to 48 750		0	1	0	1	0	0	1	0	0	0	1
48 750 to 48 850		0	1	0	1	0	1	1	0	0	0	1
48 850 to 48 950		0	1	0	1	0	1	1	0	0	1	1
48 950 to 49 050		0	1	0	1	0	1	1	0	0	1	0
49 050 to 49 150		0	1	0	1	0	1	1	0	1	1	0
49 150 to 49 250		0	1	0	1	0	1	1	0	1	0	0
49 250 to 49 350		0	1	0	1	0	1	1	1	1	0	0
49 350 to 49 450		0	1	0	1	0	1	1	1	1	1	0
49 450 to 49 550		0	1	0	1	0	1	1	1	0	1	0
49 550 to 49 650		0	1	0	1	0	1	1	1	0	1	1
49 650 to 49 750		0	1	0	1	0	1	1	1	0	0	1
49 750 to 49 850		0	1	0	1	0	1	0	1	0	0	1
49 850 to 49 950		0	1	0	1	0	1	0	1	0	1	1
49 950 to 50 050		0	1	0	1	0	1	0	1	0	1	0
50 050 to 50 150		0	1	0	1	0	1	0	1	1	1	0
50 150 to 50 250		0	1	0	1	0	1	0	1	1	0	0
50 250 to 50 350		0	1	0	1	0	1	0	0	1	0	0
50 350 to 50 450		0	1	0	1	0	1	0	0	1	1	0
50 450 to 50 550		0	1	0	1	0	1	0	0	0	1	0
50 550 to 50 650		0	1	0	1	0	1	0	0	0	1	1
50 650 to 50 750		0	1	0	1	0	1	0	0	0	0	1
50 750 to 50 850		0	1	0	1	1	1	0	0	0	0	1
50 850 to 50 950		0	1	0	1	1	1	0	0	0	1	1
50 950 to 51 050		0	1	0	1	1	1	0	0	0	1	0
51 050 to 51 150		0	1	0	1	1	1	0	0	1	1	0
51 150 to 51 250		0	1	0	1	1	1	0	0	1	0	0
51 250 to 51 350		0	1	0	1	1	1	0	1	1	0	0
51 350 to 51 450		0	1	0	1	1	1	0	1	1	1	0
51 450 to 51 550		0	1	0	1	1	1	0	1	0	1	0
51 550 to 51 650		0	1	0	1	1	1	0	1	0	1	1
51 650 to 51 750		0	1	0	1	1	1	0	1	0	0	1
51 750 to 51 850		0	1	0	1	1	1	1	1	0	0	1
51 850 to 51 950		0	1	0	1	1	1	1	1	0	1	1
51 950 to 52 050		0	1	0	1	1	1	1	1	0	1	0
52 050 to 52 150		0	1	0	1	1	1	1	1	1	1	0
52 150 to 52 250		0	1	0	1	1	1	1	1	1	0	0

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)									
Increments (Feet)			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
52 250	to	52 350	0	1	0	1	1	1	1	0	1	0	0
52 350	to	52 450	0	1	0	1	1	1	1	0	1	1	0
52 450	to	52 550	0	1	0	1	1	1	1	0	0	1	0
52 550	to	52 650	0	1	0	1	1	1	1	0	0	1	1
52 650	to	52 750	0	1	0	1	1	1	1	0	0	0	1
52 750	to	52 850	0	1	0	1	1	0	1	0	0	0	1
52 850	to	52 950	0	1	0	1	1	0	1	0	0	1	1
52 950	to	53 050	0	1	0	1	1	0	1	0	0	1	0
53 050	to	53 150	0	1	0	1	1	0	1	0	1	1	0
53 150	to	53 250	0	1	0	1	1	0	1	0	1	0	0
53 250	to	53 350	0	1	0	1	1	0	1	1	1	0	0
53 350	to	53 450	0	1	0	1	1	0	1	1	1	1	0
53 450	to	53 550	0	1	0	1	1	0	1	1	0	1	0
53 550	to	53 650	0	1	0	1	1	0	1	1	0	1	1
53 650	to	53 750	0	1	0	1	1	0	1	1	0	0	1
53 750	to	53 850	0	1	0	1	1	0	0	1	0	0	1
53 850	to	53 950	0	1	0	1	1	0	0	1	0	1	1
53 950	to	54 050	0	1	0	1	1	0	0	1	0	1	0
54 050	to	54 150	0	1	0	1	1	0	0	1	1	1	0
54 150	to	54 250	0	1	0	1	1	0	0	1	1	0	0
54 250	to	54 350	0	1	0	1	1	0	0	0	1	0	0
54 350	to	54 450	0	1	0	1	1	0	0	0	1	1	0
54 450	to	54 550	0	1	0	1	1	0	0	0	0	1	0
54 550	to	54 650	0	1	0	1	1	0	0	0	0	1	1
54 650	to	54 750	0	1	0	1	1	0	0	0	0	0	1
54 750	to	54 850	0	1	0	0	1	0	0	0	0	0	1
54 850	to	54 950	0	1	0	0	1	0	0	0	0	1	1
54 950	to	55 050	0	1	0	0	1	0	0	0	0	1	0
55 050	to	55 150	0	1	0	0	1	0	0	0	1	1	0
55 150	to	55 250	0	1	0	0	1	0	0	0	1	0	0
55 250	to	55 350	0	1	0	0	1	0	0	1	1	0	0
55 350	to	55 450	0	1	0	0	1	0	0	1	1	1	0
55 450	to	55 550	0	1	0	0	1	0	0	1	0	1	0
55 550	to	55 650	0	1	0	0	1	0	0	1	0	1	1
55 650	to	55 750	0	1	0	0	1	0	0	1	0	0	1
55 750	to	55 850	0	1	0	0	1	0	1	1	0	0	1
55 850	to	55 950	0	1	0	0	1	0	1	1	0	1	1
55 950	to	56 050	0	1	0	0	1	0	1	1	0	1	0
56 050	to	56 150	0	1	0	0	1	0	1	1	1	1	0
56 150	to	56 250	0	1	0	0	1	0	1	1	1	0	0
56 250	to	56 350	0	1	0	0	1	0	1	0	1	0	0
56 350	to	56 450	0	1	0	0	1	0	1	0	1	1	0
56 450	to	56 550	0	1	0	0	1	0	1	0	0	1	0
56 550	to	56 650	0	1	0	0	1	0	1	0	0	1	1
56 650	to	56 750	0	1	0	0	1	0	1	0	0	0	1

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
56750 to 56850		0	1	0	0	1	1	1	0	0	0	1
56850 to 56950		0	1	0	0	1	1	1	0	0	1	1
56950 to 57050		0	1	0	0	1	1	1	0	0	1	0
57050 to 57150		0	1	0	0	1	1	1	0	1	1	0
57150 to 57250		0	1	0	0	1	1	1	0	1	0	0
57250 to 57350		0	1	0	0	1	1	1	1	1	0	0
57350 to 57450		0	1	0	0	1	1	1	1	1	1	0
57450 to 57550		0	1	0	0	1	1	1	1	0	1	0
57550 to 57650		0	1	0	0	1	1	1	1	0	1	1
57650 to 57750		0	1	0	0	1	1	1	1	0	0	1
57750 to 57850		0	1	0	0	1	1	0	1	0	0	1
57850 to 57950		0	1	0	0	1	1	0	1	0	1	1
57950 to 58050		0	1	0	0	1	1	0	1	0	1	0
58050 to 58150		0	1	0	0	1	1	0	1	1	1	0
58150 to 58250		0	1	0	0	1	1	0	1	1	0	0
58250 to 58350		0	1	0	0	1	1	0	0	1	0	0
58350 to 58450		0	1	0	0	1	1	0	0	1	1	0
58450 to 58550		0	1	0	0	1	1	0	0	0	1	0
58550 to 58650		0	1	0	0	1	1	0	0	0	1	1
58650 to 58750		0	1	0	0	1	1	0	0	0	0	1
58750 to 58850		0	1	0	0	0	1	0	0	0	0	1
58850 to 58950		0	1	0	0	0	1	0	0	0	1	1
58950 to 59050		0	1	0	0	0	1	0	0	0	1	0
59050 to 59150		0	1	0	0	0	1	0	0	1	1	0
59150 to 59250		0	1	0	0	0	1	0	0	1	0	0
59250 to 59350		0	1	0	0	0	1	0	1	1	0	0
59350 to 59450		0	1	0	0	0	1	0	1	1	1	0
59450 to 59550		0	1	0	0	0	1	0	1	0	1	0
59550 to 59650		0	1	0	0	0	1	0	1	0	1	1
59650 to 59750		0	1	0	0	0	1	0	1	0	0	1
59750 to 59850		0	1	0	0	0	1	1	1	0	0	1
59850 to 59950		0	1	0	0	0	1	1	1	0	1	1
59950 to 60050		0	1	0	0	0	1	1	1	0	1	0
60050 to 60150		0	1	0	0	0	1	1	1	1	1	0
60150 to 60250		0	1	0	0	0	1	1	1	1	0	0
60250 to 60350		0	1	0	0	0	1	1	0	1	0	0
60350 to 60450		0	1	0	0	0	1	1	0	1	1	0
60450 to 60550		0	1	0	0	0	1	1	0	0	1	0
60550 to 60650		0	1	0	0	0	1	1	0	0	1	1
60650 to 60750		0	1	0	0	0	1	1	0	0	0	1
60750 to 60850		0	1	0	0	0	0	1	0	0	0	1
60850 to 60950		0	1	0	0	0	0	1	0	0	1	1
60950 to 61050		0	1	0	0	0	0	1	0	0	1	0
61050 to 61150		0	1	0	0	0	0	1	0	1	1	0
61150 to 61250		0	1	0	0	0	0	1	0	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)									
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
61 250 to 61 350		0	1	0	0	0	0	1	1	1	0	0
61 350 to 61 450		0	1	0	0	0	0	1	1	1	1	0
61 450 to 61 550		0	1	0	0	0	0	1	1	0	1	0
61 550 to 61 650		0	1	0	0	0	0	1	1	0	1	1
61 650 to 61 750		0	1	0	0	0	0	1	1	0	0	1
61 750 to 61 850		0	1	0	0	0	0	0	1	0	0	1
61 850 to 61 950		0	1	0	0	0	0	0	1	0	1	1
61 950 to 62 050		0	1	0	0	0	0	0	1	0	1	0
62 050 to 62 150		0	1	0	0	0	0	0	1	1	1	0
62 150 to 62 250		0	1	0	0	0	0	0	1	1	0	0
62 250 to 62 350		0	1	0	0	0	0	0	0	1	0	0
62 350 to 62 450		0	1	0	0	0	0	0	0	1	1	0
62 450 to 62 550		0	1	0	0	0	0	0	0	0	1	0
62 550 to 62 650		0	1	0	0	0	0	0	0	0	1	1
62 650 to 62 750		0	1	0	0	0	0	0	0	0	0	1
62 750 to 62 850		1	1	0	0	0	0	0	0	0	0	1
62 850 to 62 950		1	1	0	0	0	0	0	0	0	1	1
62 950 to 63 050		1	1	0	0	0	0	0	0	0	1	0
63 050 to 63 150		1	1	0	0	0	0	0	0	1	1	0
63 150 to 63 250		1	1	0	0	0	0	0	0	1	0	0
63 250 to 63 350		1	1	0	0	0	0	0	1	1	0	0
63 350 to 63 450		1	1	0	0	0	0	0	1	1	1	0
63 450 to 63 550		1	1	0	0	0	0	0	1	0	1	0
63 550 to 63 650		1	1	0	0	0	0	0	1	0	1	1
63 650 to 63 750		1	1	0	0	0	0	0	1	0	0	1
63 750 to 63 850		1	1	0	0	0	0	1	1	0	0	1
63 850 to 63 950		1	1	0	0	0	0	1	1	0	1	1
63 950 to 64 050		1	1	0	0	0	0	1	1	0	1	0
64 050 to 64 150		1	1	0	0	0	0	1	1	1	1	0
64 150 to 64 250		1	1	0	0	0	0	1	1	1	0	0
64 250 to 64 350		1	1	0	0	0	0	1	0	1	0	0
64 350 to 64 450		1	1	0	0	0	0	1	0	1	1	0
64 450 to 64 550		1	1	0	0	0	0	1	0	0	1	0
64 550 to 64 650		1	1	0	0	0	0	1	0	0	1	1
64 650 to 64 750		1	1	0	0	0	0	1	0	0	0	1
64 750 to 64 850		1	1	0	0	0	1	1	0	0	0	1
64 850 to 64 950		1	1	0	0	0	1	1	0	0	1	1
64 950 to 65 050		1	1	0	0	0	1	1	0	0	1	0
65 050 to 65 150		1	1	0	0	0	1	1	0	1	1	0
65 150 to 65 250		1	1	0	0	0	1	1	0	1	0	0
65 250 to 65 350		1	1	0	0	0	1	1	1	1	0	0
65 350 to 65 450		1	1	0	0	0	1	1	1	1	1	0
65 450 to 65 550		1	1	0	0	0	1	1	1	0	1	0
65 550 to 65 650		1	1	0	0	0	1	1	1	0	1	1
65 650 to 65 750		1	1	0	0	0	1	1	1	0	0	1

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_1	D_2	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
65 750 to 65 850	1	1	0	0	0	1	0	1	0	0	1
65 850 to 65 950	1	1	0	0	0	1	0	1	0	1	1
65 950 to 66 050	1	1	0	0	0	1	0	1	0	1	0
66 050 to 66 150	1	1	0	0	0	1	0	1	1	1	0
66 150 to 66 250	1	1	0	0	0	1	0	1	1	0	0
66 250 to 66 350	1	1	0	0	0	1	0	0	1	0	0
66 350 to 66 450	1	1	0	0	0	1	0	0	1	1	0
66 450 to 66 550	1	1	0	0	0	1	0	0	0	1	0
66 550 to 66 650	1	1	0	0	0	1	0	0	0	1	1
66 650 to 66 750	1	1	0	0	0	1	0	0	0	0	1
66 750 to 66 850	1	1	0	0	1	1	0	0	0	0	1
66 850 to 66 950	1	1	0	0	1	1	0	0	0	1	1
66 950 to 67 050	1	1	0	0	1	1	0	0	0	1	0
67 050 to 67 150	1	1	0	0	1	1	0	0	1	1	0
67 150 to 67 250	1	1	0	0	1	1	0	0	1	0	0
67 250 to 67 350	1	1	0	0	1	1	0	1	1	0	0
67 350 to 67 450	1	1	0	0	1	1	0	1	1	1	0
67 450 to 67 550	1	1	0	0	1	1	0	1	0	1	0
67 550 to 67 650	1	1	0	0	1	1	0	1	0	1	1
67 650 to 67 750	1	1	0	0	1	1	0	1	0	0	1
67 750 to 67 850	1	1	0	0	1	1	1	1	0	0	1
67 850 to 67 950	1	1	0	0	1	1	1	1	0	1	1
67 950 to 68 050	1	1	0	0	1	1	1	1	0	1	0
68 050 to 68 150	1	1	0	0	1	1	1	1	1	1	0
68 150 to 68 250	1	1	0	0	1	1	1	1	1	0	0
68 250 to 68 350	1	1	0	0	1	1	1	0	1	0	0
68 350 to 68 450	1	1	0	0	1	1	1	0	1	1	0
68 450 to 68 550	1	1	0	0	1	1	1	0	0	1	0
68 550 to 68 650	1	1	0	0	1	1	1	0	0	1	1
68 650 to 68 750	1	1	0	0	1	1	1	0	0	0	1
68 750 to 68 850	1	1	0	0	1	0	1	0	0	0	1
68 850 to 68 950	1	1	0	0	1	0	1	0	0	1	1
68 950 to 69 050	1	1	0	0	1	0	1	0	0	1	0
69 050 to 69 150	1	1	0	0	1	0	1	0	1	1	0
69 150 to 69 250	1	1	0	0	1	0	1	0	1	0	0
69 250 to 69 350	1	1	0	0	1	0	1	1	1	0	0
69 350 to 69 450	1	1	0	0	1	0	1	1	1	1	0
69 450 to 69 550	1	1	0	0	1	0	1	1	0	1	0
69 550 to 69 650	1	1	0	0	1	0	1	1	0	1	1
69 650 to 69 750	1	1	0	0	1	0	1	1	0	0	1
69 750 to 69 850	1	1	0	0	1	0	0	1	0	0	1
69 850 to 69 950	1	1	0	0	1	0	0	1	0	1	1
69 950 to 70 050	1	1	0	0	1	0	0	1	0	1	0
70 050 to 70 150	1	1	0	0	1	0	0	1	1	1	0
70 150 to 70 250	1	1	0	0	1	0	0	1	1	0	0

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_1	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
70 250 to 70 350	1	1	0	0	1	0	0	0	1	0	0
70 350 to 70 450	1	1	0	0	1	0	0	0	1	1	0
70 450 to 70 550	1	1	0	0	1	0	0	0	0	1	0
70 550 to 70 650	1	1	0	0	1	0	0	0	0	1	1
70 650 to 70 750	1	1	0	0	1	0	0	0	0	0	1
70 750 to 70 850	1	1	0	1	1	0	0	0	0	0	1
70 850 to 70 950	1	1	0	1	1	0	0	0	0	1	1
70 950 to 71 050	1	1	0	1	1	0	0	0	0	1	0
71 050 to 71 150	1	1	0	1	1	0	0	0	1	1	0
71 150 to 71 250	1	1	0	1	1	0	0	0	1	0	0
71 250 to 71 350	1	1	0	1	1	0	0	1	1	0	0
71 350 to 71 450	1	1	0	1	1	0	0	1	1	1	0
71 450 to 71 550	1	1	0	1	1	0	0	1	0	1	0
71 550 to 71 650	1	1	0	1	1	0	0	1	0	1	1
71 650 to 71 750	1	1	0	1	1	0	0	1	0	0	1
71 750 to 71 850	1	1	0	1	1	0	1	1	0	0	1
71 850 to 71 950	1	1	0	1	1	0	1	1	0	1	1
71 950 to 72 050	1	1	0	1	1	0	1	1	0	1	0
72 050 to 72 150	1	1	0	1	1	0	1	1	1	1	0
72 150 to 72 250	1	1	0	1	1	0	1	1	1	0	0
72 250 to 72 350	1	1	0	1	1	0	1	0	1	0	0
72 350 to 72 450	1	1	0	1	1	0	1	0	1	1	0
72 450 to 72 550	1	1	0	1	1	0	1	0	0	1	0
72 550 to 72 650	1	1	0	1	1	0	1	0	0	1	1
72 650 to 72 750	1	1	0	1	1	0	1	0	0	0	1
72 750 to 72 850	1	1	0	1	1	1	1	0	0	0	1
72 850 to 72 950	1	1	0	1	1	1	1	0	0	1	1
72 950 to 73 050	1	1	0	1	1	1	1	0	0	1	0
73 050 to 73 150	1	1	0	1	1	1	1	0	1	1	0
73 150 to 73 250	1	1	0	1	1	1	1	0	1	0	0
73 250 to 73 350	1	1	0	1	1	1	1	1	1	0	0
73 350 to 73 450	1	1	0	1	1	1	1	1	1	1	0
73 450 to 73 550	1	1	0	1	1	1	1	1	0	1	0
73 550 to 73 650	1	1	0	1	1	1	1	1	0	1	1
73 650 to 73 750	1	1	0	1	1	1	1	1	0	0	1
73 750 to 73 850	1	1	0	1	1	1	0	1	0	0	1
73 850 to 73 950	1	1	0	1	1	1	0	1	0	1	1
73 950 to 74 050	1	1	0	1	1	1	0	1	0	1	0
74 050 to 74 150	1	1	0	1	1	1	0	1	1	1	0
74 150 to 74 250	1	1	0	1	1	1	0	1	1	0	0
74 250 to 74 350	1	1	0	1	1	1	0	0	1	0	0
74 350 to 74 450	1	1	0	1	1	1	0	0	1	1	0
74 450 to 74 550	1	1	0	1	1	1	0	0	0	1	0
74 550 to 74 650	1	1	0	1	1	1	0	0	0	1	1
74 650 to 74 750	1	1	0	1	1	1	0	0	0	0	1

RANGE	PULSE POSITIONS
Increments (feet)	(0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)

Increments (feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_3	C_2	C_1
74 750 to 74 850		1	1	0	1	0	1	0	0	0	0	1
74 850 to 74 950		1	1	0	1	0	1	0	0	0	1	1
74 950 to 75 050		1	1	0	1	0	1	0	0	0	1	0
75 050 to 75 150		1	1	0	1	0	1	0	0	1	1	0
75 150 to 75 250		1	1	0	1	0	1	0	0	1	0	0
75 250 to 75 350		1	1	0	1	0	1	0	1	1	0	0
75 350 to 75 450		1	1	0	1	0	1	0	1	1	1	0
75 450 to 75 550		1	1	0	1	0	1	0	1	0	1	0
75 550 to 75 650		1	1	0	1	0	1	0	1	0	1	1
75 650 to 75 750		1	1	0	1	0	1	0	1	0	0	1
75 750 to 75 850		1	1	0	1	0	1	1	1	0	0	1
75 850 to 75 950		1	1	0	1	0	1	1	1	0	1	1
75 950 to 76 050		1	1	0	1	0	1	1	1	0	1	0
76 050 to 76 150		1	1	0	1	0	1	1	1	1	1	0
76 150 to 76 250		1	1	0	1	0	1	1	1	1	0	0
76 250 to 76 350		1	1	0	1	0	1	1	0	1	0	0
76 350 to 76 450		1	1	0	1	0	1	1	0	1	1	0
76 450 to 76 550		1	1	0	1	0	1	1	0	0	1	0
76 550 to 76 650		1	1	0	1	0	1	1	0	0	1	1
76 650 to 76 750		1	1	0	1	0	1	1	0	0	0	1
76 750 to 76 850		1	1	0	1	0	0	1	0	0	0	1
76 850 to 76 950		1	1	0	1	0	0	1	0	0	1	1
76 950 to 77 050		1	1	0	1	0	0	1	0	0	1	0
77 050 to 77 150		1	1	0	1	0	0	1	0	1	1	0
77 150 to 77 250		1	1	0	1	0	0	1	0	1	0	0
77 250 to 77 350		1	1	0	1	0	0	1	1	1	0	0
77 350 to 77 450		1	1	0	1	0	0	1	1	1	1	0
77 450 to 77 550		1	1	0	1	0	0	1	1	0	1	0
77 550 to 77 650		1	1	0	1	0	0	1	1	0	1	1
77 650 to 77 750		1	1	0	1	0	0	1	1	0	0	1
77 750 to 77 850		1	1	0	1	0	0	0	1	0	0	1
77 850 to 77 950		1	1	0	1	0	0	0	1	0	1	1
77 950 to 78 050		1	1	0	1	0	0	0	1	0	1	0
78 050 to 78 150		1	1	0	1	0	0	0	1	1	1	0
78 150 to 78 250		1	1	0	1	0	0	0	1	1	0	0
78 250 to 78 350		1	1	0	1	0	0	0	0	1	0	0
78 350 to 78 450		1	1	0	1	0	0	0	0	1	1	0
78 450 to 78 550		1	1	0	1	0	0	0	0	0	1	0
78 550 to 78 650		1	1	0	1	0	0	0	0	0	1	1
78 650 to 78 750		1	1	0	1	0	0	0	0	0	0	1
78 750 to 78 850		1	1	1	1	0	0	0	0	0	0	1
78 850 to 78 950		1	1	1	1	0	0	0	0	0	1	1
78 950 to 79 050		1	1	1	1	0	0	0	0	0	1	0
79 050 to 79 150		1	1	1	1	0	0	0	0	1	1	0
79 150 to 79 250		1	1	1	1	0	0	0	0	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Freq)		D_2	D_1	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
79 250 to 79 350		1	1	1	1	0	0	0	1	1	0	0
79 350 to 79 450		1	1	1	1	0	0	0	1	1	1	0
79 450 to 79 550		1	1	1	1	0	0	0	1	0	1	0
79 550 to 79 650		1	1	1	1	0	0	0	1	0	1	1
79 650 to 79 750		1	1	1	1	0	0	0	1	0	0	1
79 750 to 79 850		1	1	1	1	0	0	1	1	0	0	1
79 850 to 79 950		1	1	1	1	0	0	1	1	0	1	1
79 950 to 80 050		1	1	1	1	0	0	1	1	0	1	0
80 050 to 80 150		1	1	1	1	0	0	1	1	1	1	0
80 150 to 80 250		1	1	1	1	0	0	1	1	1	0	0
80 250 to 80 350		1	1	1	1	0	0	1	0	1	0	0
80 350 to 80 450		1	1	1	1	0	0	1	0	1	1	0
80 450 to 80 550		1	1	1	1	0	0	1	0	0	1	0
80 550 to 80 650		1	1	1	1	0	0	1	0	0	1	1
80 650 to 80 750		1	1	1	1	0	0	1	0	0	0	1
80 750 to 80 850		1	1	1	1	0	1	1	0	0	0	1
80 850 to 80 950		1	1	1	1	0	1	1	0	0	1	1
80 950 to 81 050		1	1	1	1	0	1	1	0	0	1	0
81 050 to 81 150		1	1	1	1	0	1	1	0	1	1	0
81 150 to 81 250		1	1	1	1	0	1	1	0	1	0	0
81 250 to 81 350		1	1	1	1	0	1	1	1	1	0	0
81 350 to 81 450		1	1	1	1	0	1	1	1	1	1	0
81 450 to 81 550		1	1	1	1	0	1	1	1	0	1	0
81 550 to 81 650		1	1	1	1	0	1	1	1	0	1	1
81 650 to 81 750		1	1	1	1	0	1	1	1	0	0	1
81 750 to 81 850		1	1	1	1	0	1	0	1	0	0	1
81 850 to 81 950		1	1	1	1	0	1	0	1	0	1	1
81 950 to 82 050		1	1	1	1	0	1	0	1	0	1	0
82 050 to 82 150		1	1	1	1	0	1	0	1	1	1	0
82 150 to 82 250		1	1	1	1	0	1	0	1	1	0	0
82 250 to 82 350		1	1	1	1	0	1	0	0	1	0	0
82 350 to 82 450		1	1	1	1	0	1	0	0	1	1	0
82 450 to 82 550		1	1	1	1	0	1	0	0	0	1	0
82 550 to 82 650		1	1	1	1	0	1	0	0	0	1	1
82 650 to 82 750		1	1	1	1	0	1	0	0	0	0	1
82 750 to 82 850		1	1	1	1	1	1	0	0	0	0	1
82 850 to 82 950		1	1	1	1	1	1	0	0	0	1	1
82 950 to 83 050		1	1	1	1	1	1	0	0	0	1	0
83 050 to 83 150		1	1	1	1	1	1	0	0	1	1	0
83 150 to 83 250		1	1	1	1	1	1	0	0	1	0	0
83 250 to 83 350		1	1	1	1	1	1	0	1	1	0	0
83 350 to 83 450		1	1	1	1	1	1	0	1	1	1	0
83 450 to 83 550		1	1	1	1	1	1	0	1	0	1	0
83 550 to 83 650		1	1	1	1	1	1	0	1	0	1	1
83 650 to 83 750		1	1	1	1	1	1	0	1	0	0	1

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_1	D_2	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
83 750 to 83 850	1	1	1	1	1	1	1	1	0	0	1
83 850 to 83 950	1	1	1	1	1	1	1	1	0	1	1
83 950 to 84 050	1	1	1	1	1	1	1	1	0	1	0
84 050 to 84 150	1	1	1	1	1	1	1	1	1	1	0
84 150 to 84 250	1	1	1	1	1	1	1	1	1	0	0
84 250 to 84 350	1	1	1	1	1	1	1	0	1	0	0
84 350 to 84 450	1	1	1	1	1	1	1	0	1	1	0
84 450 to 84 550	1	1	1	1	1	1	1	0	0	1	0
84 550 to 84 650	1	1	1	1	1	1	1	0	0	1	1
84 650 to 84 750	1	1	1	1	1	1	1	0	0	0	1
84 750 to 84 850	1	1	1	1	1	0	1	0	0	0	1
84 850 to 84 950	1	1	1	1	1	0	1	0	0	1	1
84 950 to 85 050	1	1	1	1	1	0	1	0	0	1	0
85 050 to 85 150	1	1	1	1	1	0	1	0	1	1	0
85 150 to 85 250	1	1	1	1	1	0	1	0	1	0	0
85 250 to 85 350	1	1	1	1	1	0	1	1	1	0	0
85 350 to 85 450	1	1	1	1	1	0	1	1	1	1	0
85 450 to 85 550	1	1	1	1	1	0	1	1	0	1	0
85 550 to 85 650	1	1	1	1	1	0	1	1	0	1	1
85 650 to 85 750	1	1	1	1	1	0	1	1	0	0	1
85 750 to 85 850	1	1	1	1	1	0	0	1	0	0	1
85 850 to 85 950	1	1	1	1	1	0	0	1	0	1	1
85 950 to 86 050	1	1	1	1	1	0	0	1	0	1	0
86 050 to 86 150	1	1	1	1	1	0	0	1	1	1	0
86 150 to 86 250	1	1	1	1	1	0	0	1	1	0	0
86 250 to 86 350	1	1	1	1	1	0	0	0	1	0	0
86 350 to 86 450	1	1	1	1	1	0	0	0	1	1	0
86 450 to 86 550	1	1	1	1	1	0	0	0	0	1	0
86 550 to 86 650	1	1	1	1	1	0	0	0	0	1	1
86 650 to 86 750	1	1	1	1	1	0	0	0	0	0	1
86 750 to 86 850	1	1	1	0	1	0	0	0	0	0	1
86 850 to 86 950	1	1	1	0	1	0	0	0	0	1	1
86 950 to 87 050	1	1	1	0	1	0	0	0	0	1	0
87 050 to 87 150	1	1	1	0	1	0	0	0	1	1	0
87 150 to 87 250	1	1	1	0	1	0	0	0	1	0	0
87 250 to 87 350	1	1	1	0	1	0	0	1	1	0	0
87 350 to 87 450	1	1	1	0	1	0	0	1	1	1	0
87 450 to 87 550	1	1	1	0	1	0	0	1	0	1	0
87 550 to 87 650	1	1	1	0	1	0	0	1	0	1	1
87 650 to 87 750	1	1	1	0	1	0	0	1	0	0	1
87 750 to 87 850	1	1	1	0	1	0	1	1	0	0	1
87 850 to 87 950	1	1	1	0	1	0	1	1	0	1	1
87 950 to 88 050	1	1	1	0	1	0	1	1	0	1	0
88 050 to 88 150	1	1	1	0	1	0	1	1	1	1	0
88 150 to 88 250	1	1	1	0	1	0	1	1	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (feet)		D_2	D_1	A_1	A_2	A_4	B_1	B_2	B_1	C_1	C_2	C_1
88 250 to 88 350		1	1	1	0	1	0	1	0	1	0	0
88 350 to 88 450		1	1	1	0	1	0	1	0	1	1	0
88 450 to 88 550		1	1	1	0	1	0	1	0	0	1	0
88 550 to 88 650		1	1	1	0	1	0	1	0	0	1	1
88 650 to 88 750		1	1	1	0	1	0	1	0	0	0	1
88 750 to 88 850		1	1	1	0	1	1	1	0	0	0	1
88 850 to 88 950		1	1	1	0	1	1	1	0	0	1	1
88 950 to 89 050		1	1	1	0	1	1	1	0	0	1	0
89 050 to 89 150		1	1	1	0	1	1	1	0	1	1	0
89 150 to 89 250		1	1	1	0	1	1	1	0	1	0	0
89 250 to 89 350		1	1	1	0	1	1	1	1	1	0	0
89 350 to 89 450		1	1	1	0	1	1	1	1	1	1	0
89 450 to 89 550		1	1	1	0	1	1	1	1	0	1	0
89 550 to 89 650		1	1	1	0	1	1	1	1	0	1	1
89 650 to 89 750		1	1	1	0	1	1	1	1	0	0	1
89 750 to 89 850		1	1	1	0	1	1	0	1	0	0	1
89 850 to 89 950		1	1	1	0	1	1	0	1	0	1	1
89 950 to 90 050		1	1	1	0	1	1	0	1	0	1	0
90 050 to 90 150		1	1	1	0	1	1	0	1	1	1	0
90 150 to 90 250		1	1	1	0	1	1	0	1	1	0	0
90 250 to 90 350		1	1	1	0	1	1	0	0	1	0	0
90 350 to 90 450		1	1	1	0	1	1	0	0	1	1	0
90 450 to 90 550		1	1	1	0	1	1	0	0	0	1	0
90 550 to 90 650		1	1	1	0	1	1	0	0	0	1	1
90 650 to 90 750		1	1	1	0	1	1	0	0	0	0	1
90 750 to 90 850		1	1	1	0	0	1	0	0	0	0	1
90 850 to 90 950		1	1	1	0	0	1	0	0	0	1	1
90 950 to 91 050		1	1	1	0	0	1	0	0	0	1	0
91 050 to 91 150		1	1	1	0	0	1	0	0	1	1	0
91 150 to 91 250		1	1	1	0	0	1	0	0	1	0	0
91 250 to 91 350		1	1	1	0	0	1	0	1	1	0	0
91 350 to 91 450		1	1	1	0	0	1	0	1	1	1	0
91 450 to 91 550		1	1	1	0	0	1	0	1	0	1	0
91 550 to 91 650		1	1	1	0	0	1	0	1	0	1	1
91 650 to 91 750		1	1	1	0	0	1	0	1	0	0	1
91 750 to 91 850		1	1	1	0	0	1	1	1	0	0	1
91 850 to 91 950		1	1	1	0	0	1	1	1	0	1	1
91 950 to 92 050		1	1	1	0	0	1	1	1	0	1	0
92 050 to 92 150		1	1	1	0	0	1	1	1	1	1	0
92 150 to 92 250		1	1	1	0	0	1	1	1	1	0	0
92 250 to 92 350		1	1	1	0	0	1	1	0	1	0	0
92 350 to 92 450		1	1	1	0	0	1	1	0	1	1	0
92 450 to 92 550		1	1	1	0	0	1	1	0	0	1	0
92 550 to 92 650		1	1	1	0	0	1	1	0	0	1	1
92 650 to 92 750		1	1	1	0	0	1	1	0	0	0	1

RANGE Increments (Feet)	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
	D_2	D_1	A_1	A_2	A_1	B_1	B_2	B_4	C_1	C_2	C_4
92 750 to 92 850	1	1	1	0	0	0	1	0	0	0	1
92 850 to 92 950	1	1	1	0	0	0	1	0	0	1	1
92 950 to 93 050	1	1	1	0	0	0	1	0	0	1	0
93 050 to 93 150	1	1	1	0	0	0	1	0	1	1	0
93 150 to 93 250	1	1	1	0	0	0	1	0	1	0	0
93 250 to 93 350	1	1	1	0	0	0	1	1	1	0	0
93 350 to 93 450	1	1	1	0	0	0	1	1	1	1	0
93 450 to 93 550	1	1	1	0	0	0	1	1	0	1	0
93 550 to 93 650	1	1	1	0	0	0	1	1	0	1	1
93 650 to 93 750	1	1	1	0	0	0	1	1	0	0	1
93 750 to 93 850	1	1	1	0	0	0	0	1	0	0	1
93 850 to 93 950	1	1	1	0	0	0	0	1	0	1	1
93 950 to 94 050	1	1	1	0	0	0	0	1	0	1	0
94 050 to 94 150	1	1	1	0	0	0	0	1	1	1	0
94 150 to 94 250	1	1	1	0	0	0	0	1	1	0	0
94 250 to 94 350	1	1	1	0	0	0	0	0	1	0	0
94 350 to 94 450	1	1	1	0	0	0	0	0	1	1	0
94 450 to 94 550	1	1	1	0	0	0	0	0	0	1	0
94 550 to 94 650	1	1	1	0	0	0	0	0	0	1	1
94 650 to 94 750	1	1	1	0	0	0	0	0	0	0	1
94 750 to 94 850	1	0	1	0	0	0	0	0	0	0	1
94 850 to 94 950	1	0	1	0	0	0	0	0	0	1	1
94 950 to 95 050	1	0	1	0	0	0	0	0	0	1	0
95 050 to 95 150	1	0	1	0	0	0	0	0	1	1	0
95 150 to 95 250	1	0	1	0	0	0	0	0	1	0	0
95 250 to 95 350	1	0	1	0	0	0	0	1	1	0	0
95 350 to 95 450	1	0	1	0	0	0	0	1	1	1	0
95 450 to 95 550	1	0	1	0	0	0	0	1	0	1	0
95 550 to 95 650	1	0	1	0	0	0	0	1	0	1	1
95 650 to 95 750	1	0	1	0	0	0	0	1	0	0	1
95 750 to 95 850	1	0	1	0	0	0	1	1	0	0	1
95 850 to 95 950	1	0	1	0	0	0	1	1	0	1	1
95 950 to 96 050	1	0	1	0	0	0	1	1	0	1	0
96 050 to 96 150	1	0	1	0	0	0	1	1	1	1	0
96 150 to 96 250	1	0	1	0	0	0	1	1	1	0	0
96 250 to 96 350	1	0	1	0	0	0	1	0	1	0	0
96 350 to 96 450	1	0	1	0	0	0	1	0	1	1	0
96 450 to 96 550	1	0	1	0	0	0	1	0	0	1	0
96 550 to 96 650	1	0	1	0	0	0	1	0	0	1	1
96 650 to 96 750	1	0	1	0	0	0	1	0	0	0	1
96 750 to 96 850	1	0	1	0	0	1	1	0	0	0	1
96 850 to 96 950	1	0	1	0	0	1	1	0	0	1	1
96 950 to 97 050	1	0	1	0	0	1	1	0	0	1	0
97 050 to 97 150	1	0	1	0	0	1	1	0	1	1	0
97 150 to 97 250	1	0	1	0	0	1	1	0	1	0	0

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_1	D_2	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
97 250 to 97 350	1	0	1	0	0	1	1	1	1	0	0
97 350 to 97 450	1	0	1	0	0	1	1	1	1	1	0
97 450 to 97 550	1	0	1	0	0	1	1	1	0	1	0
97 550 to 97 650	1	0	1	0	0	1	1	1	0	1	1
97 650 to 97 750	1	0	1	0	0	1	1	1	0	0	1
97 750 to 97 850	1	0	1	0	0	1	0	1	0	0	1
97 850 to 97 950	1	0	1	0	0	1	0	1	0	1	1
97 950 to 98 050	1	0	1	0	0	1	0	1	0	1	0
98 050 to 98 150	1	0	1	0	0	1	0	1	1	1	0
98 150 to 98 250	1	0	1	0	0	1	0	1	1	0	0
98 250 to 98 350	1	0	1	0	0	1	0	0	1	0	0
98 350 to 98 450	1	0	1	0	0	1	0	0	1	1	0
98 450 to 98 550	1	0	1	0	0	1	0	0	0	1	0
98 550 to 98 650	1	0	1	0	0	1	0	0	0	1	1
98 650 to 98 750	1	0	1	0	0	1	0	0	0	0	1
98 750 to 98 850	1	0	1	0	1	1	0	0	0	0	1
98 850 to 98 950	1	0	1	0	1	1	0	0	0	1	1
98 950 to 99 050	1	0	1	0	1	1	0	0	0	1	0
99 050 to 99 150	1	0	1	0	1	1	0	0	1	1	0
99 150 to 99 250	1	0	1	0	1	1	0	0	1	0	0
99 250 to 99 350	1	0	1	0	1	1	0	1	1	0	0
99 350 to 99 450	1	0	1	0	1	1	0	1	1	1	0
99 450 to 99 550	1	0	1	0	1	1	0	1	0	1	0
99 550 to 99 650	1	0	1	0	1	1	0	1	0	1	1
99 650 to 99 750	1	0	1	0	1	1	0	1	0	0	1
99 750 to 99 850	1	0	1	0	1	1	1	1	0	0	1
99 850 to 99 950	1	0	1	0	1	1	1	1	0	1	1
99 950 to 100 050	1	0	1	0	1	1	1	1	0	1	0
100 050 to 100 150	1	0	1	0	1	1	1	1	1	1	0
100 150 to 100 250	1	0	1	0	1	1	1	1	1	0	0
100 250 to 100 350	1	0	1	0	1	1	1	0	1	0	0
100 350 to 100 450	1	0	1	0	1	1	1	0	1	1	0
100 450 to 100 550	1	0	1	0	1	1	1	0	0	1	0
100 550 to 100 650	1	0	1	0	1	1	1	0	0	1	1
100 650 to 100 750	1	0	1	0	1	1	1	0	0	0	1
100 750 to 100 850	1	0	1	0	1	0	1	0	0	0	1
100 850 to 100 950	1	0	1	0	1	0	1	0	0	1	1
100 950 to 101 050	1	0	1	0	1	0	1	0	0	1	0
101 050 to 101 150	1	0	1	0	1	0	1	0	1	1	0
101 150 to 101 250	1	0	1	0	1	0	1	0	1	0	0
101 250 to 101 350	1	0	1	0	1	0	1	1	1	0	0
101 350 to 101 450	1	0	1	0	1	0	1	1	1	1	0
101 450 to 101 550	1	0	1	0	1	0	1	1	0	1	0
101 550 to 101 650	1	0	1	0	1	0	1	1	0	1	1
101 650 to 101 750	1	0	1	0	1	0	1	1	0	0	1

RANGE			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)									
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
101 750	to 101 850	1	0	1	0	1	0	0	1	0	0	1
101 850	to 101 950	1	0	1	0	1	0	0	1	0	1	1
101 950	to 102 050	1	0	1	0	1	0	0	1	0	1	0
102 050	to 102 150	1	0	1	0	1	0	0	1	1	1	0
102 150	to 102 250	1	0	1	0	1	0	0	1	1	0	0
102 250	to 102 350	1	0	1	0	1	0	0	0	1	0	0
102 350	to 102 450	1	0	1	0	1	0	0	0	1	1	0
102 450	to 102 550	1	0	1	0	1	0	0	0	0	1	0
102 550	to 102 650	1	0	1	0	1	0	0	0	0	1	1
102 650	to 102 750	1	0	1	0	1	0	0	0	0	0	1
102 750	to 102 850	1	0	1	1	1	0	0	0	0	0	1
102 850	to 102 950	1	0	1	1	1	0	0	0	0	1	1
102 950	to 103 050	1	0	1	1	1	0	0	0	0	1	0
103 050	to 103 150	1	0	1	1	1	0	0	0	1	1	0
103 150	to 103 250	1	0	1	1	1	0	0	0	1	0	0
103 250	to 103 350	1	0	1	1	1	0	0	1	1	0	0
103 350	to 103 450	1	0	1	1	1	0	0	1	1	1	0
103 450	to 103 550	1	0	1	1	1	0	0	1	0	1	0
103 550	to 103 650	1	0	1	1	1	0	0	1	0	1	1
103 650	to 103 750	1	0	1	1	1	0	0	1	0	0	1
103 750	to 103 850	1	0	1	1	1	0	1	1	0	0	1
103 850	to 103 950	1	0	1	1	1	0	1	1	0	1	1
103 950	to 104 050	1	0	1	1	1	0	1	1	0	1	0
104 050	to 104 150	1	0	1	1	1	0	1	1	1	1	0
104 150	to 104 250	1	0	1	1	1	0	1	1	1	0	0
104 250	to 104 350	1	0	1	1	1	0	1	0	1	0	0
104 350	to 104 450	1	0	1	1	1	0	1	0	1	1	0
104 450	to 104 550	1	0	1	1	1	0	1	0	0	1	0
104 550	to 104 650	1	0	1	1	1	0	1	0	0	1	1
104 650	to 104 750	1	0	1	1	1	0	1	0	0	0	1
104 750	to 104 850	1	0	1	1	1	1	1	0	0	0	1
104 850	to 104 950	1	0	1	1	1	1	1	0	0	1	1
104 950	to 105 050	1	0	1	1	1	1	1	0	0	1	0
105 050	to 105 150	1	0	1	1	1	1	1	0	1	1	0
105 150	to 105 250	1	0	1	1	1	1	1	0	1	0	0
105 250	to 105 350	1	0	1	1	1	1	1	1	1	0	0
105 350	to 105 450	1	0	1	1	1	1	1	1	1	1	0
105 450	to 105 550	1	0	1	1	1	1	1	1	0	1	0
105 550	to 105 650	1	0	1	1	1	1	1	1	0	1	1
105 650	to 105 750	1	0	1	1	1	1	1	1	0	0	1
105 750	to 105 850	1	0	1	1	1	1	0	1	0	0	1
105 850	to 105 950	1	0	1	1	1	1	0	1	0	1	1
105 950	to 106 050	1	0	1	1	1	1	0	1	0	1	0
106 050	to 106 150	1	0	1	1	1	1	0	1	1	1	0
106 150	to 106 250	1	0	1	1	1	1	0	1	1	0	0

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
106 250 to 106 350		1	0	1	1	1	1	0	0	1	0	0
106 350 to 106 450		1	0	1	1	1	1	0	0	1	1	0
106 450 to 106 550		1	0	1	1	1	1	0	0	0	1	0
106 550 to 106 650		1	0	1	1	1	1	0	0	0	1	1
106 650 to 106 750		1	0	1	1	1	1	0	0	0	0	1
106 750 to 106 850		1	0	1	1	0	1	0	0	0	0	1
106 850 to 106 950		1	0	1	1	0	1	0	0	0	1	1
106 950 to 107 050		1	0	1	1	0	1	0	0	0	1	0
107 050 to 107 150		1	0	1	1	0	1	0	0	1	1	0
107 150 to 107 250		1	0	1	1	0	1	0	0	1	0	0
107 250 to 107 350		1	0	1	1	0	1	0	1	1	0	0
107 350 to 107 450		1	0	1	1	0	1	0	1	1	1	0
107 450 to 107 550		1	0	1	1	0	1	0	1	0	1	0
107 550 to 107 650		1	0	1	1	0	1	0	1	0	1	1
107 650 to 107 750		1	0	1	1	0	1	0	1	0	0	1
107 750 to 107 850		1	0	1	1	0	1	1	1	0	0	1
107 850 to 107 950		1	0	1	1	0	1	1	1	0	1	1
107 950 to 108 050		1	0	1	1	0	1	1	1	0	1	0
108 050 to 108 150		1	0	1	1	0	1	1	1	1	1	0
108 150 to 108 250		1	0	1	1	0	1	1	1	1	0	0
108 250 to 108 350		1	0	1	1	0	1	1	0	1	0	0
108 350 to 108 450		1	0	1	1	0	1	1	0	1	1	0
108 450 to 108 550		1	0	1	1	0	1	1	0	0	1	0
108 550 to 108 650		1	0	1	1	0	1	1	0	0	1	1
108 650 to 108 750		1	0	1	1	0	1	1	0	0	0	1
108 750 to 108 850		1	0	1	1	0	0	1	0	0	0	1
108 850 to 108 950		1	0	1	1	0	0	1	0	0	1	1
108 950 to 109 050		1	0	1	1	0	0	1	0	0	1	0
109 050 to 109 150		1	0	1	1	0	0	1	0	1	1	0
109 150 to 109 250		1	0	1	1	0	0	1	0	1	0	0
109 250 to 109 350		1	0	1	1	0	0	1	1	1	0	0
109 350 to 109 450		1	0	1	1	0	0	1	1	1	1	0
109 450 to 109 550		1	0	1	1	0	0	1	1	0	1	0
109 550 to 109 650		1	0	1	1	0	0	1	1	0	1	1
109 650 to 109 750		1	0	1	1	0	0	1	1	0	0	1
109 750 to 109 850		1	0	1	1	0	0	0	1	0	0	1
109 850 to 109 950		1	0	1	1	0	0	0	1	0	1	1
109 950 to 110 050		1	0	1	1	0	0	0	1	0	1	0
110 050 to 110 150		1	0	1	1	0	0	0	1	1	1	0
110 150 to 110 250		1	0	1	1	0	0	0	1	1	0	0
110 250 to 110 350		1	0	1	1	0	0	0	0	1	0	0
110 350 to 110 450		1	0	1	1	0	0	0	0	1	1	0
110 450 to 110 550		1	0	1	1	0	0	0	0	0	1	0
110 550 to 110 650		1	0	1	1	0	0	0	0	0	1	1
110 650 to 110 750		1	0	1	1	0	0	0	0	0	0	1

RANGE Increments (Feet)		D_1	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
110 750	to 110 850	1	0	0	1	0	0	0	0	0	0	1
110 850	to 110 950	1	0	0	1	0	0	0	0	0	1	1
110 950	to 111 050	1	0	0	1	0	0	0	0	0	1	0
111 050	to 111 150	1	0	0	1	0	0	0	0	1	1	0
111 150	to 111 250	1	0	0	1	0	0	0	0	1	0	0
111 250	to 111 350	1	0	0	1	0	0	0	1	1	0	0
111 350	to 111 450	1	0	0	1	0	0	0	1	1	1	0
111 450	to 111 550	1	0	0	1	0	0	0	1	0	1	0
111 550	to 111 650	1	0	0	1	0	0	0	1	0	1	1
111 650	to 111 750	1	0	0	1	0	0	0	1	0	0	1
111 750	to 111 850	1	0	0	1	0	0	1	1	0	0	1
111 850	to 111 950	1	0	0	1	0	0	1	1	0	1	1
111 950	to 112 050	1	0	0	1	0	0	1	1	0	1	0
112 050	to 112 150	1	0	0	1	0	0	1	1	1	1	0
112 150	to 112 250	1	0	0	1	0	0	1	1	1	0	0
112 250	to 112 350	1	0	0	1	0	0	1	0	1	0	0
112 350	to 112 450	1	0	0	1	0	0	1	0	1	1	0
112 450	to 112 550	1	0	0	1	0	0	1	0	0	1	0
112 550	to 112 650	1	0	0	1	0	0	1	0	0	1	1
112 650	to 112 750	1	0	0	1	0	0	1	0	0	0	1
112 750	to 112 850	1	0	0	1	0	1	1	0	0	0	1
112 850	to 112 950	1	0	0	1	0	1	1	0	0	1	1
112 950	to 113 050	1	0	0	1	0	1	1	0	0	1	0
113 050	to 113 150	1	0	0	1	0	1	1	0	1	1	0
113 150	to 113 250	1	0	0	1	0	1	1	0	1	0	0
113 250	to 113 350	1	0	0	1	0	1	1	1	1	0	0
113 350	to 113 450	1	0	0	1	0	1	1	1	1	1	0
113 450	to 113 550	1	0	0	1	0	1	1	1	0	1	0
113 550	to 113 650	1	0	0	1	0	1	1	1	0	1	1
113 650	to 113 750	1	0	0	1	0	1	1	1	0	0	1
113 750	to 113 850	1	0	0	1	0	1	0	1	0	0	1
113 850	to 113 950	1	0	0	1	0	1	0	1	0	1	1
113 950	to 114 050	1	0	0	1	0	1	0	1	0	1	0
114 050	to 114 150	1	0	0	1	0	1	0	1	1	1	0
114 150	to 114 250	1	0	0	1	0	1	0	1	1	0	0
114 250	to 114 350	1	0	0	1	0	1	0	0	1	0	0
114 350	to 114 450	1	0	0	1	0	1	0	0	1	1	0
114 450	to 114 550	1	0	0	1	0	1	0	0	0	1	0
114 550	to 114 650	1	0	0	1	0	1	0	0	0	1	1
114 650	to 114 750	1	0	0	1	0	1	0	0	0	0	1
114 750	to 114 850	1	0	0	1	1	1	0	0	0	0	1
114 850	to 114 950	1	0	0	1	1	1	0	0	0	1	1
114 950	to 115 050	1	0	0	1	1	1	0	0	0	1	0
115 050	to 115 150	1	0	0	1	1	1	0	0	1	1	0
115 150	to 115 250	1	0	0	1	1	1	0	0	1	0	0

PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
115 250 to 115 350		1	0	0	1	1	1	0	1	1	0	0
115 350 to 115 450		1	0	0	1	1	1	0	1	1	1	0
115 450 to 115 550		1	0	0	1	1	1	0	1	0	1	0
115 550 to 115 650		1	0	0	1	1	1	0	1	0	1	1
115 650 to 115 750		1	0	0	1	1	1	0	1	0	0	1
115 750 to 115 850		1	0	0	1	1	1	1	1	0	0	1
115 850 to 115 950		1	0	0	1	1	1	1	1	0	1	1
115 950 to 116 050		1	0	0	1	1	1	1	1	0	1	0
116 050 to 116 150		1	0	0	1	1	1	1	1	1	1	0
116 150 to 116 250		1	0	0	1	1	1	1	1	1	0	0
116 250 to 116 350		1	0	0	1	1	1	1	0	1	0	0
116 350 to 116 450		1	0	0	1	1	1	1	0	1	1	0
116 450 to 116 550		1	0	0	1	1	1	1	0	0	1	0
116 550 to 116 650		1	0	0	1	1	1	1	0	0	1	1
116 650 to 116 750		1	0	0	1	1	1	1	0	0	0	1
116 750 to 116 850		1	0	0	1	1	0	1	0	0	0	1
116 850 to 116 950		1	0	0	1	1	0	1	0	0	1	1
116 950 to 117 050		1	0	0	1	1	0	1	0	0	1	0
117 050 to 117 150		1	0	0	1	1	0	1	0	1	1	0
117 150 to 117 250		1	0	0	1	1	0	1	0	1	0	0
117 250 to 117 350		1	0	0	1	1	0	1	1	1	0	0
117 350 to 117 450		1	0	0	1	1	0	1	1	1	1	0
117 450 to 117 550		1	0	0	1	1	0	1	1	0	1	0
117 550 to 117 650		1	0	0	1	1	0	1	1	0	1	1
117 650 to 117 750		1	0	0	1	1	0	1	1	0	0	1
117 750 to 117 850		1	0	0	1	1	0	0	1	0	0	1
117 850 to 117 950		1	0	0	1	1	0	0	1	0	1	1
117 950 to 118 050		1	0	0	1	1	0	0	1	0	1	0
118 050 to 118 150		1	0	0	1	1	0	0	1	1	1	0
118 150 to 118 250		1	0	0	1	1	0	0	1	1	0	0
118 250 to 118 350		1	0	0	1	1	0	0	0	1	0	0
118 350 to 118 450		1	0	0	1	1	0	0	0	1	1	0
118 450 to 118 550		1	0	0	1	1	0	0	0	0	1	0
118 550 to 118 650		1	0	0	1	1	0	0	0	0	1	1
118 650 to 118 750		1	0	0	1	1	0	0	0	0	0	1
118 750 to 118 850		1	0	0	0	1	0	0	0	0	0	1
118 850 to 118 950		1	0	0	0	1	0	0	0	0	1	1
118 950 to 119 050		1	0	0	0	1	0	0	0	0	1	0
119 050 to 119 150		1	0	0	0	1	0	0	0	1	1	0
119 150 to 119 250		1	0	0	0	1	0	0	0	1	0	0
119 250 to 119 350		1	0	0	0	1	0	0	1	1	0	0
119 350 to 119 450		1	0	0	0	1	0	0	1	1	1	0
119 450 to 119 550		1	0	0	0	1	0	0	1	0	1	0
119 550 to 119 650		1	0	0	0	1	0	0	1	0	1	1
119 650 to 119 750		1	0	0	0	1	0	0	1	0	0	1

RANGE		PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)		D_1	D_4	A_1	A_2	A_1	B_2	B_1	B_1	C_1	C_2	C_4
119 750	to 119 850	1	0	0	0	1	0	1	1	0	0	1
119 850	to 119 950	1	0	0	0	1	0	1	1	0	1	1
119 950	to 120 050	1	0	0	0	1	0	1	1	0	1	0
120 050	to 120 150	1	0	0	0	1	0	1	1	1	1	0
120 150	to 120 250	1	0	0	0	1	0	1	1	1	0	0
120 250	to 120 350	1	0	0	0	1	0	1	0	1	0	0
120 350	to 120 450	1	0	0	0	1	0	1	0	1	1	0
120 450	to 120 550	1	0	0	0	1	0	1	0	0	1	0
120 550	to 120 650	1	0	0	0	1	0	1	0	0	1	1
120 650	to 120 750	1	0	0	0	1	0	1	0	0	0	1
120 750	to 120 850	1	0	0	0	1	1	1	0	0	0	1
120 850	to 120 950	1	0	0	0	1	1	1	0	0	1	1
120 950	to 121 050	1	0	0	0	1	1	1	0	0	1	0
121 050	to 121 150	1	0	0	0	1	1	1	0	1	1	0
121 150	to 121 250	1	0	0	0	1	1	1	0	1	0	0
121 250	to 121 350	1	0	0	0	1	1	1	1	1	0	0
121 350	to 121 450	1	0	0	0	1	1	1	1	1	1	0
121 450	to 121 550	1	0	0	0	1	1	1	1	0	1	0
121 550	to 121 650	1	0	0	0	1	1	1	1	0	1	1
121 650	to 121 750	1	0	0	0	1	1	1	1	0	0	1
121 750	to 121 850	1	0	0	0	1	1	0	1	0	0	1
121 850	to 121 950	1	0	0	0	1	1	0	1	0	1	1
121 950	to 122 050	1	0	0	0	1	1	0	1	0	1	0
122 050	to 122 150	1	0	0	0	1	1	0	1	1	1	0
122 150	to 122 250	1	0	0	0	1	1	0	1	1	0	0
122 250	to 122 350	1	0	0	0	1	1	0	0	1	0	0
122 350	to 122 450	1	0	0	0	1	1	0	0	1	1	0
122 450	to 122 550	1	0	0	0	1	1	0	0	0	1	0
122 550	to 122 650	1	0	0	0	1	1	0	0	0	1	1
122 650	to 122 750	1	0	0	0	1	1	0	0	0	0	1
122 750	to 122 850	1	0	0	0	0	1	0	0	0	0	1
122 850	to 122 950	1	0	0	0	0	1	0	0	0	1	1
122 950	to 123 050	1	0	0	0	0	1	0	0	0	1	0
123 050	to 123 150	1	0	0	0	0	1	0	0	1	1	0
123 150	to 123 250	1	0	0	0	0	1	0	0	1	0	0
123 250	to 123 350	1	0	0	0	0	1	0	1	1	0	0
123 350	to 123 450	1	0	0	0	0	1	0	1	1	1	0
123 450	to 123 550	1	0	0	0	0	1	0	1	0	1	0
123 550	to 123 650	1	0	0	0	0	1	0	1	0	1	1
123 650	to 123 750	1	0	0	0	0	1	0	1	0	0	1
123 750	to 123 850	1	0	0	0	0	1	1	1	0	0	1
123 850	to 123 950	1	0	0	0	0	1	1	1	0	1	1
123 950	to 124 050	1	0	0	0	0	1	1	1	0	1	0
124 050	to 124 150	1	0	0	0	0	1	1	1	1	1	0
124 150	to 124 250	1	0	0	0	0	1	1	1	1	0	0

RANGE	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
Increments (Feet)	D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
124 250 to 124 350	1	0	0	0	0	1	1	0	1	0	0
124 350 to 124 450	1	0	0	0	0	1	1	0	1	1	0
124 450 to 124 550	1	0	0	0	0	1	1	0	0	1	0
124 550 to 124 650	1	0	0	0	0	1	1	0	0	1	1
124 650 to 124 750	1	0	0	0	0	1	1	0	0	0	1
124 750 to 124 850	1	0	0	0	0	0	1	0	0	0	1
124 850 to 124 950	1	0	0	0	0	0	1	0	0	1	1
124 950 to 125 050	1	0	0	0	0	0	1	0	0	1	0
125 050 to 125 150	1	0	0	0	0	0	1	0	1	1	0
125 150 to 125 250	1	0	0	0	0	0	1	0	1	0	0
125 250 to 125 350	1	0	0	0	0	0	1	1	1	0	0
125 350 to 125 450	1	0	0	0	0	0	1	1	1	1	0
125 450 to 125 550	1	0	0	0	0	0	1	1	0	1	0
125 550 to 125 650	1	0	0	0	0	0	1	1	0	1	1
125 650 to 125 750	1	0	0	0	0	0	1	1	0	0	1
125 750 to 125 850	1	0	0	0	0	0	0	1	0	0	1
125 850 to 125 950	1	0	0	0	0	0	0	1	0	1	1
125 950 to 126 050	1	0	0	0	0	0	0	1	0	1	0
126 050 to 126 150	1	0	0	0	0	0	0	1	1	1	0
126 150 to 126 250	1	0	0	0	0	0	0	1	1	0	0
126 250 to 126 350	1	0	0	0	0	0	0	0	1	0	0
126 350 to 126 450	1	0	0	0	0	0	0	0	1	1	0
126 450 to 126 550	1	0	0	0	0	0	0	0	0	1	0
126 550 to 126 650	1	0	0	0	0	0	0	0	0	1	1
126 650 to 126 750	1	0	0	0	0	0	0	0	0	0	1

SCHEDULE 2

ACAS SYSTEM

(Reg. : 28, 30, 32, 37, 39, 40, 47, 48, 50, 54, 56-59, 63 and 65)

1.   Mode A/C ACAS I interference limits.

n_a	Upper limit for $(\sum_{k=1}^{k_1} P_a(k))$	
	If $f_r \le 240$	*If $f_r > 240$*
0	250	118
1	250	113
2	250	108
3	250	103
4	250	98
5	250	94
6	250	89
7	250	84
8	250	79
9	250	74
10	245	70
11	228	65
12	210	60
13	193	55
14	175	50
15	158	45
16	144	41
17	126	36
18	109	31
19	91	26
20	74	21
21	60	17
≥ 22	42	12

where:

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

{ }   =   average value of the expression within the brackets over last 8 interrogation cycles.

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

k =   index number for Mode A/C interrogations, $k = 1, 2, .., k_1$;

k_1 =   number of Mode A/C interrogations transmitted in a 1 s interrogation cycle;

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

2. Surveillance performance requirements for ACAS

Table 2-1 : ACAS design assumptions

Conditions									Performance
Quadrant						Maximum traffic density		Maximum number of other ACAS within 56 km (30 NM)	
Forward		Side		Back					
Maximum closing speed						aircraft/ km²	aircraft/ NM²		Probability of success
m/s	kt	m/s	kt	m/s	kt				
260	500	150	300	93	180	0.087	0.30	30	0.9
620	1 200	390	750	220	430	0.017	0.06	30	0.9

3. ACAS interference limiting inequalities.

$$\left(\sum_{i=1}^{k}\left[\frac{p(i)}{250}\right]^{\alpha}\right) < minimum\left[\frac{280}{1+n_a},\frac{11}{\alpha^2}\right] \qquad (1)$$

$$\left(\sum_{i=1}^{k} m(i)\right) < 0.01 \qquad (2)$$

$$\left(\frac{1}{B}\sum_{k=1}^{k}\frac{P_a(k)}{250}\right) < minimum\left[\frac{80}{1+n_a},3\right] \qquad (3)$$

Note.— RA and ACAS broadcasts are interrogations.

The variables in these inequalities shall be defined as follows:

i_t = number of interrogations (Mode A/C and Mode S) transmitted in a 1 s interrogation

cycle. This shall include all Mode S interrogations used by the ACAS functions, including those in addition to UF = 0 and UF = 16 interrogations, except as provided in 2.2.2.2.1;

Note.— UF = 19 interrogations are included in i_t as specified in 1.1.2.8.9.4.

i =   index number for Mode A/C and Mode S interrogations, $i = 1, 2, ..., i_t$;

α =   the minimum of α_1 calculated as $1/4$ $[n_b/n_c]$ subject to the special conditions given

below and α_2 calculated as Log_{10} $[n_a/n_b]$ / Log_{10} 25, where n_b and n_c are defined as the number of operating ACAS II and ACAS III equipped aircraft (airborne or on the ground) within 11.2 km (6 NM) and 5.6 km (3 NM) respectively, of own ACAS (based on ACAS surveillance). ACAS aircraft operating on the ground or at or below a radio altitude of 610 m (2 000 ft) AGL shall include both airborne and on-ground ACAS II and ACAS III aircraft in the value for n_b and n_c. Otherwise, ACAS shall include only airborne ACAS II and ACAS III aircraft in the value for n_b and n_c. The values of α, α_1 and α_2 are further constrained to a minimum of 0.5 and a maximum of 1.0.

In addition;

IF $[(n_b \leq 1)$ OR $(n_b \leq 4$ AND $n_c < 2$ AND $n_a > 25)]$ THEN $\alpha_1 = 1.0$;

IF $[(n_c > 2)$ AND $(n_b > 2\, n_c)$ AND $(n_a < 40)]$ THEN $\alpha_1 \cdot 0.5$;

$p(i)$ · peak power radiated from the antenna in all directions of the pulse having the largest amplitude in the group of pulses comprising a single interrogation during the ith interrogation in a 1 s interrogation cycle, W;

$m(i)$ = duration of the mutual suppression interval for own transponder associated with the ith interrogation in a 1 s interrogation cycle, s;

B =   beam sharpening factor (ratio of 3 dB beam width to beamwidth resulting from interrogation side-lobe suppression). For ACAS interrogators that employ transmitter side-lobe suppression (SLS), the appropriate beamwidth shall be the extent in azimuth angle of the Mode A/C replies from one transponder as limited by SLS, averaged over the transponder population;

$\{\ \}$ see 4.2.3.3.3

$P_a(k)$ "

k "

| kt | " |
| na | " |

Note.— RA and ACAS broadcasts (4.3.6.2.1 and 4.3.7.1.2.4) are interrogations.

4. THREAT DETECTION IN ACAS

Table 2-2

Sensitivity level	2	3	4	5	6	7
Nominal warning time	no RAs	15s	20s	25s	30s	35s

5. Signal Formats
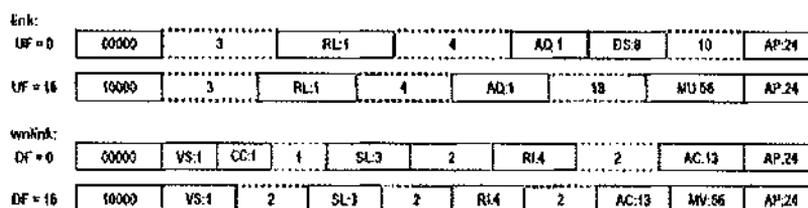
Figure 2-1: Surveillance and Communication formats used by ACAS

5.1. Fields and Subfields Introduced in Schedule 1, 1.1.2.

5.1.1. DR (downlink request). The significance of the coding of the downlink request field shall be as follows –

Coding
2   See Schedule 1, 1.1.2.6.5.2
3   ACAS message available
4   Comm-B message available and ACAS message available
4-5   See Schedule 1, 1.1.2.6.5.2
6   Comm-B broadcast message 1 available and ACAS message available
7   Comm-B broadcast message 2 available and ACAS message available
8-31   See Schedule 1, 1.1.2.6.5.2

5.1.2. RI (air-air reply information). The significance of the coding in the RI field shall be as follows --

Coding
0   No operating ACAS
1   Not assigned
2   ACAS with resolution capability inhibited
3   ACAS with vertical-only resolution capability

4   ACAS with vertical and horizontal resolution capability
5-7   Not assigned
8-15   Schedule 1, 1.1.2.8.2.2

Bit 14 of the reply format containing this field shall replicate the AQ bit of the interrogation. The RI field shall report "no operating ACAS" (RI = 0) if the ACAS unit has failed or is in standby. The RI field shall report "ACAS with resolution capability inhibited" (RI = 2) if sensitivity level is 2 or TA only mode has been selected.

Note.— 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.

5.1.3.   *RR (reply request)*. The significance of the coding in the reply request field shall be as follows:
Coding
0-18   See regulation 47(3)
19   Transmit a resolution advisory report
20-31   See regulation 47(3)

6.   ACAS FIELDS AND SUBFIELDS

6.1. Subfield in MA

6.1.1.   *ADS (A-definition subfield)*. This 8-bit (33-40) subfield shall define the remainder of MA.

Note.— For convenience of coding, ADS is expressed in two groups of four bits each, ADS1 and ADS2.

6.1.2.   *When ADS1 = 0 and ADS2 = 5, the following subfield shall be contained in MA:*

6.1.3.   *SLC (ACAS sensitivity level control (SLC) command)*. This 4-bit (41-44) subfield shall denote a sensitivity level command for own ACAS.

Coding

   0   No command issued

   1   Not assigned

   2   Set ACAS sensitivity level to 2

   3   Set ACAS sensitivity level to 3

   4   Set ACAS sensitivity level to 4

   5   Set ACAS sensitivity level to 5

   6   Set ACAS sensitivity level to 6

 7-14   Not assigned

  15   Cancel previous SLC command from this ground station

Note.— Structure of MA for a sensitivity level control command:

33	37	41	45
ADS1 = 0	ADS2 = 6	SLC	· · · · 44 · · · ·
36	40	44	88
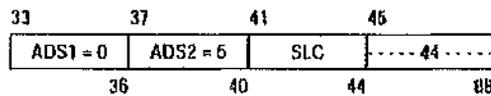
6.2. Subfields in MB

6.2.1.   Subfields in MB for an RA report. When BDS1=3 and BDS2=0, the subfields indicated below shall be contained in MB.

6.2.1.1.   Subfields in MB for an RA report. When BDS1=3 and BDS2=0, the subfields indicated below shall be contained in MB.

6.2.1.1.1.   ARA (active RAs). This 14-bit (41-54) subfield shall indicate the characteristics of the RA, if any, generated by the ACAS associated with the transponder transmitting the subfield. The bits in ARA shall have meanings determined by the value of the MTE subfield and, for vertical RAs, the value of bit 41 of ARA. The meaning of bit 41 of ARA shall be as follows –

Coding

0   There is more than one threat and the RA is intended to provide separation below some threat(s) and above some other threat(s) or no RA has been generated (when MTE = 0)

1   Either there is only one threat or the RA is intended to provide separation in the same direction for all threats

When ARA bit 41 = 1 and MTE = 0 or 1, bits 42-47 shall have the following meanings:

When ARA bit 41 = 1 and MTE = 0 or 1, bits 42-47 shall have the following meanings:

Bit	Coding	
42	0	RA is preventive
	1	RA is corrective
43	0	Upward sense RA has been generated
	1	Downward sense RA has been generated
44	0	RA is not increased rate
	1	RA is increased rate
45	0	RA is not a sense reversal
	1	RA is a sense reversal
46	0	RA is not altitude crossing
	1	RA is altitude crossing
47	0	RA is vertical speed limit
	1	RA is positive
48-54		Reserved for ACAS III

When ARA bit 41 = 0 and MTE = 1, bits 42-47 shall have the following meanings:

Bit	Coding	
42	0	RA does not require a correction in the upward sense
	1	RA requires a correction in the upward sense
43	0	RA does not require a positive climb
	1	RA requires a positive climb
44	0	RA does not require a correction in the downward sense
	1	RA requires a correction in the downward sense
45	0	RA does not require a positive descend
	1	RA requires a positive descend
46	0	RA does not require a crossing
	1	RA requires a crossing
47	0	RA is not a sense reversal
	1	RA is a sense reversal
48-54		Reserved for ACAS III

Note.— When ARA bit 41 = 0 and MTE = 0, no vertical RA has been generated.

6.2.1.1.2.   *RAC (RACs record).* This 4-bit (55-58) subfield shall indicate all the currently active RACs, if any, received from other ACAS aircraft. The bits in RAC shall have the following meanings:

Bit	Resolution advisory complement
55	Do not pass below
56	Do not pass above
57	Do not turn left
58	Do not turn right

A bit set to 1 shall indicate that the associated RAC is active. A bit set to 0 shall indicate that the associated RAC is inactive.

6.2.1.1.3. *RAT (RA terminated indicator).* This 1-bit (59) subfield shall indicate when an RA previously generated by ACAS has ceased being generated.

Coding

0   ACAS is currently generating the RA indicated in the ARA subfield

1   The RA indicated by the ARA subfield has been terminated

> Note 1.— After an RA has been terminated by ACAS, it is still required to be reported by the Mode S transponder for 18±1 s. 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.

6.2.1.1.4. *MTE (multiple threat encounter).* This 1-bit (60) subfield shall indicate whether two or more simultaneous threats are currently being processed by the ACAS threat resolution logic.

Coding

0   One threat is being processed by the resolution logic (when ARA bit 41 = 1); or no threat is being processed by the resolution logic (when ARA bit 41 = 0)

1   Two or more simultaneous threats are being processed by the resolution logic

6.2.1.1.5. *TTI (threat type indicator subfield).* This 2-bit subfield (61-62) shall define the type of identity data contained in the TID subfield.

Coding

0	No identity data in TID
1	TID contains a Mode S transponder address
2	TID contains altitude, range and bearing data
3	Not assigned

6.2.1.1.6. *TID (threat identity data subfield).* This 26-bit subfield (63-88) shall contain the Mode S address of the threat or the altitude, range, and bearing if the threat is not Mode S equipped. If two or more threats are simultaneously processed by the ACAS resolution logic, TID shall contain the identity or position data for the most recently declared threat. If TTI = 1, TID shall contain in bits 63-86 the aircraft address of the threat, and bits 87 and 88 shall be set to 0. If TTI = 2, TID shall contain the following three subfields.

6.2.1.1.6.1. TIDA (threat identity data altitude subfield). This 13-bit subfield (63-75) shall contain the most recently reported Mode C altitude code of the threat

Coding

Bit	63	64	65	66	67	68	69	70	71	72	73	74	75
Mode C code bit	C_1	A_1	C_2	A_2	C_4	A_4	0	B_1	D_1	B_2	D_2	B_4	D_4

6.2.1.1.6.2. *TIDR (threat identity data range subfield).* This 7-bit subfield (76-82) shall contain the most recent threat range estimated by ACAS.

Coding (n)

n	Estimated range (NM)
0	No range estimate available
1	Less than 0.05
2-126	$(n-1)/10 \pm 0.05$
127	Greater than 12.55

6.2.1.1.6.3. *TIDB (threat identity data bearing subfield).* This 6-bit subfield (83-88) shall contain the most recent estimated bearing of the threat aircraft, relative to the ACAS aircraft heading.

Coding (n)

n	Estimated bearing (degrees)
0	No bearing estimate available
1-60	Between $6(n-1)$ and $6n$
61-63	*Not assigned*

Note.— Structure of MB for an RA report:

```
33      37      41      55      59      60      61      63
BDS1=3 BDS2=0   ARA     RAC     RAT     MTE    TTI=1          FID
    36      40      54      58      59      60      62              88

33      37      41      55      59      60      61      63      78      83
BDS1=3 BDS2=0   ARA     RAC     RAT     MTE    TTI=2   TIDA    TIDR    TIDB
    36      40      54      58      59      60      62      75      82      88
```
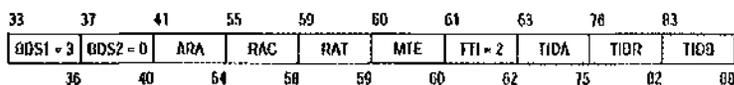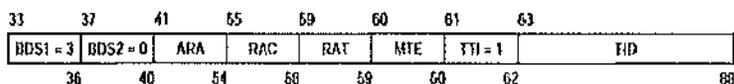
6.2.2. *Subfields in MB for the data link capability report.* When BDS1 = 1 and BDS2 = 0, the following bit patterns shall be provided to the transponder for its data link capability report –

Bit	*Coding*
48	0 ACAS failed or on standby
	1 ACAS operating
69	0 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 & EUROCAE ED 143
1	1	Reserved for future versions (see *Note 3*)

Note 1.— A summary of the MB subfields for the data link capability report structure is described in Schedule 1, 1.1.2.6.10.2.2.

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

Note 3.— Future versions of ACAS will be identified using part numbers and software version numbers specified in registers E516 and E616.

7. *MU field.* This 56-bit (33-88) field of long air-air surveillance interrogations (Figure 2-1) shall be used to transmit resolution messages, ACAS broadcasts and RA broadcasts.

7.1. UDS (U-definition subfield). This 8-bit (33-40) subfield shall define the remainder of MU.

Note.— For convenience in coding, UDS is expressed in two groups of four bits each, UDS1 and UDS2.

7.2. Subfields in MU for a resolution message. When UDS1 - 3 and UDS2 = 0 the following subfields shall be contained in MU:

7.2.1. MTB (Multiple Threat Bit). This 1-bit (42) subfield shall indicate the presence or absence of multiple threats.

7.2.2. M Subfields in MU for a resolution message. When UDS1 - 3 and UDS2 = 0 the following subfields shall be contained in MU.

7.2.2.1 MTB (multiple threat bit). This 1-bit (42) subfield shall indicate the presence or absence of multiple threats.

> *Coding*
> 0   Interrogating ACAS has one threat
> 1   Interrogating ACAS has more than one threat

7.2.2.1. *VRC (vertical RAC).* This 2-bit (45-46) subfield shall denote a vertical RAC relating to the addressed aircraft.

> *Coding*
> 0   No vertical RAC sent
> 1   Do not pass below
> 2   Do not pass above
> 3   Not assigned

7.2.2.2. *CVC (cancel vertical RAC).* This 2-bit (43-44) subfield shall denote the cancellation of a vertical RAC previously sent to the addressed aircraft. This subfield shall be set to 0 for a new threat.

> *Coding*
> 0   No cancellation
> 1   Cancel previously sent "Do not pass below"
> 2   Cancel previously sent "Do not pass above"
> 3   Not assigned

7.2.2.3. *HRC (horizontal RAC).* This 3-bit (50-52) subfield shall denote a horizontal RAC relating to the addressed aircraft.

> *Coding*
> 0   No horizontal RAC or no horizontal resolution capability
> 1   Other ACAS sense is turn left; do not turn left
> 2   Other ACAS sense is turn left; do not turn right
> 3   Not assigned
> 4   Not assigned
> 5   Other ACAS sense is turn right; do not turn left
> 6   Other ACAS sense is turn right; do not turn right
> 7   Not assigned

7.2.2.4. *CHC (cancel horizontal RAC)*. This 3-bit (47-49) subfield shall denote the cancellation of a horizontal RAC previously sent to the addressed aircraft. This subfield shall be set to 0 for a new threat.

> *Coding*
> 0   No cancellation or no horizontal resolution capability
> 1   Cancel previously sent "Do not turn left"
> 2   Cancel previously sent "Do not turn right"
> 3-7   Not assigned

7.2.2.5. *VSB (vertical sense bits subfield)*. This 4-bit (61-64) subfield shall be used to protect the data in the CVC and VRC subfields. For each of the 16 possible combinations of bits 43-46 the following VSB code shall be transmitted:

	CVC		VRC		VSB			
Coding	43	44	45	46	61	62	63	64
0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	1	0
2	0	0	1	0	0	1	1	1
3	0	0	1	1	1	0	0	1
4	0	1	0	0	1	0	1	1
5	0	1	0	1	0	1	0	1
6	0	1	1	0	1	1	0	0
7	0	1	1	1	0	0	1	0
8	1	0	0	0	1	1	0	1
9	1	0	0	1	0	0	1	1
10	1	0	1	0	1	0	1	0
11	1	0	1	1	0	1	0	0
12	1	1	0	0	0	1	1	0
13	1	1	0	1	1	0	0	0
14	1	1	1	0	0	0	0	1
15	1	1	1	1	1	1	1	1

Note.— The rule used to generate the VSB subfield bit setting is a distance 3 Hamming code augmented with a parity bit, producing the ability to detect up to three errors in the eight transmitted bits.

7.2.2.6. *HSB (horizontal sense bits subfield)*. This 5-bit (56-60) subfield shall be used to protect the data in the CHC and HRC subfields. For each of the 64 possible combinations of bits 47-52 the following HSB code shall be transmitted:

Coding	CHC				HRC		HSB				
	47	48	49	50	51	52	56	57	58	59	60
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	1	0	1	0	1	1
2	0	0	0	0	1	0	1	0	0	1	1
3	0	0	0	0	1	1	1	1	0	0	0
4	0	0	0	1	0	0	1	1	1	0	0
5	0	0	0	1	0	1	1	0	1	1	1
6	0	0	0	1	1	0	0	1	1	1	1
7	0	0	0	1	1	1	0	0	1	0	0
8	0	0	1	0	0	0	0	1	1	0	1
9	0	0	1	0	0	1	0	0	1	1	0
10	0	0	1	0	1	0	1	1	1	1	0
11	0	0	1	0	1	1	1	0	1	0	1
12	0	0	1	1	0	0	1	0	0	0	1
13	0	0	1	1	0	1	1	1	0	1	0
14	0	0	1	1	1	0	0	0	0	1	0
15	0	0	1	1	1	1	0	1	0	0	1
16	0	1	0	0	0	0	1	0	1	0	1
17	0	1	0	0	0	1	1	1	1	1	0
18	0	1	0	0	1	0	0	0	1	1	0
19	0	1	0	0	1	1	0	1	1	0	1
20	0	1	0	1	0	0	0	1	0	0	1
21	0	1	0	1	0	1	0	0	0	1	0
22	0	1	0	1	1	0	1	1	0	1	0
23	0	1	0	1	1	1	1	0	0	0	1
24	0	1	1	0	0	0	1	1	0	0	0
25	0	1	1	0	0	1	1	0	0	1	1

Coding	CHC				HRC		HSB				
	47	48	49	50	51	52	56	57	58	59	60
26	0	1	1	0	1	0	0	1	0	1	1
27	0	1	1	0	1	1	0	0	0	0	0
28	0	1	1	1	0	0	0	0	1	0	0
29	0	1	1	1	0	1	0	1	1	1	1
30	0	1	1	1	1	0	1	0	1	1	1
31	0	1	1	1	1	1	1	1	1	0	0
32	1	0	0	0	0	0	1	1	0	0	1
33	1	0	0	0	0	1	1	0	0	1	0
34	1	0	0	0	1	0	0	1	0	1	0
35	1	0	0	0	1	1	0	0	0	0	1
36	1	0	0	1	0	0	0	0	1	0	1
37	1	0	0	1	0	1	0	1	1	1	0
38	1	0	0	1	1	0	1	0	1	1	0
39	1	0	0	1	1	1	1	1	1	0	1
40	1	0	1	0	0	0	1	0	1	0	0
41	1	0	1	0	0	1	1	1	1	1	1
42	1	0	1	0	1	0	0	0	1	1	1
43	1	0	1	0	1	1	0	1	1	0	0
44	1	0	1	1	0	0	0	1	0	0	0
45	1	0	1	1	0	1	0	0	0	1	1
46	1	0	1	1	1	0	1	1	0	1	1
47	1	0	1	1	1	1	1	0	0	0	0
48	1	1	0	0	0	0	0	1	1	0	0
49	1	1	0	0	0	1	0	0	1	1	1
50	1	1	0	0	1	0	1	1	1	1	1
51	1	1	0	0	1	1	1	0	1	0	0
52	1	1	0	1	0	0	1	0	0	0	0
53	1	1	0	1	0	1	1	1	0	1	1
54	1	1	0	1	1	0	0	0	0	1	1
55	1	1	0	1	1	1	0	1	0	0	0
56	1	1	1	0	0	0	0	0	0	0	1
57	1	1	1	0	0	1	0	1	0	1	0
58	1	1	1	0	1	0	1	0	0	1	0
59	1	1	1	0	1	1	1	1	0	0	1
60	1	1	1	1	0	0	1	1	1	0	1
61	1	1	1	1	0	1	1	0	1	1	0
62	1	1	1	1	1	0	0	1	1	1	0
63	1	1	1	1	1	1	0	0	1	0	1

Note.— The rule used to generate the HSB subfield bit setting is a distance 3 Hamming code augmented with a parity bit, producing the ability to detect up to three errors in the eleven transmitted bits.

7.2.2.7. *MID (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 a resolution message:

33	37	41	42	43	45	47	50	53	56	61	65
UDS1 = 3	UDS2 = 0	-1-	MTB	CVC	VRC	CHC	HRC	-3-	HSB	VSB	MID
36	40	41	42	44	46	49	52	55	60	64	88
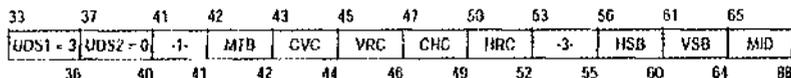
7.2.3. *Subfield in MU for an ACAS broadcast.* When UDS1 = 3 and UDS2 = 2, the following subfield shall be contained in MU:

7.2.3.1. *MID (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 ACAS broadcast:

33	37	41	65
UDS1 = 3	UDS2 = 2	- - - - - 24 - - - - -	MID
36	40	64	88
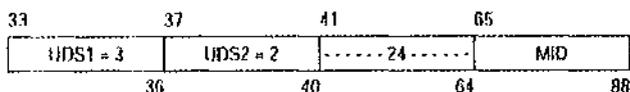
7.2.4. *Subfields in MU for an RA broadcast.* When UDS1 = 3 and UDS2 = 1, the following subfields shall be contained in MU:

7.2.4.1. *ARA (active RAs).* This 14-bit (41-54) subfield shall be coded as defined in 6.1.2.1.1.

7.2.4.2. *RAC (RACs record).* This 4-bit (55-58) subfield shall be coded as defined in 6.1.2.1.2.

7.2.4.3. *RAT (RA terminated indicator).* This 1-bit (59) subfield shall be coded as defined in 6.1.2.1.3.

7.2.4.4. *MTE (multiple threat encounter).* This 1-bit (60) subfield shall be coded as defined in 6.1.2.1.4.

7.2.4.5. *AID (Mode A identity code).* This 13-bit (63-75) subfield shall denote the Mode A identity code of the reporting aircraft.

Coding

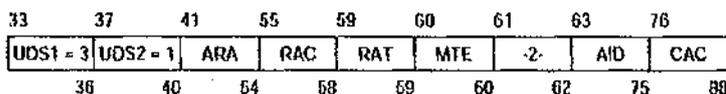| Bit	63	64	65	66	67	68	69	70	71	72	73	74	75
Mode A code bit	A_1	A_2	A_4	B_1	B_2	B_4	0	C_4	C_2	C_1	D_4	D_2	D_1

7.2.4.6.   *CAC (Mode C altitude code).* This 13-bit (76-88) subfield shall denote the Mode C altitude code of the reporting aircraft.

Coding

Bit	76	77	78	79	80	81	82	83	84	85	86	87	88
Mode C code bit	C_1	A_1	C_2	A_2	C_4	A_4	0	B_1	D_1	B_2	D_2	B_4	D_4

Note. — Structure of MU for an RA broadcast:

33	37	41	55	59	60	61	63	76
UDS1 = 3	UDS2 = 1	ARA	RAC	RAT	MTE	-2-	AID	CAC
36	40	54	58	59	60	62	75	88

8.   *MV field.* This 56-bit (33-88) field of long air-air surveillance replies (Figure 2-1) shall be used to transmit air-air coordination reply messages.

8.1.   *VDS (V-definition subfield).* This 8-bit (33-40) subfield shall define the remainder of MV.

Note.— For convenience in coding, VDS is expressed in two groups of four bits each, VDS1 and VDS2.

8.2.   *Subfields in MV for a coordination reply.* When VDS1 = 3 and VDS2 = 0, the following subfields shall be contained in MV:

8.2.1.   *ARA (active RAs).* This 14-bit (41-54) subfield shall be coded as defined in 1.2.1.1.

8.2.2.   *RAC (RACs record).* This 4-bit (55-58) subfield shall be coded as defined in 1.2.1.2.

8.2.3.   *RAT (RA terminated indicator).* This 1-bit (59) subfield shall be coded as defined in 1.2.1.3.

8.2.4.   *MTE (multiple threat encounter).* This 1-bit (60) subfield shall be coded as defined in 1.2.1.4.

Note.— Structure of MV for a coordination reply:

33	37	41	55	59	60	61
VDS1 = 3	VDS2 = 0	ARA	RAC	RAT	MTE	-28-
36	40	54	58	59	60	88

8.2.5.   *SL (sensitivity level report)*. This 3-bit (9-11) downlink field shall be included in both short and long air-air reply formats (DF = 0 and 16). This field shall denote the sensitivity level at which ACAS is currently operating.

> *Coding*
> 0   ACAS inoperative
> 1   ACAS is operating at sensitivity level 1
> 2   ACAS is operating at sensitivity level 2
> 3   ACAS is operating at sensitivity level 3
> 4   ACAS is operating at sensitivity level 4
> 5   ACAS is operating at sensitivity level 5
> 6   ACAS is operating at sensitivity level 6
> 7   ACAS is operating at sensitivity level 7

8.2.6.   *CC: Cross-link capability*. This 1-bit (7) downlink field shall indicate the ability of the transponder to support the cross-link capability, that is, decode the contents of the DS field in an interrogation with UF equals 0 and respond with the contents of the specified GICB register in the corresponding reply with DF equals 16.

Coding

0   signifies that the transponder cannot support the cross-link capability.

1   signifies that the transponder supports the cross-link capability.

9.   Performance of the ACAS II Collision Avoidance Logic

Note - Caution is to be observed when considering potential improvements to the reference ACAS II system described in Section 4 of the guidance material in the Attachment 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.

9.1.   *Altitude* layer. Each encounter is attributed to one of six altitude layers as follows:

Layer	1	2	3	4	5	6
from		2 300 ft	5 000 ft	10 000 ft	20 000 ft	41 000 ft
to	2 300 ft	5 000 ft	10 000 ft	20 000 ft	41 000 ft	

The altitude layer of an encounter is determined by the average altitude of the two aircraft at closest approach.

Note - For the purposes of defining the performance of the collision avoidance logic, there is no need to specify the physical basis of the altitude measurement or the relationship between altitude and ground level.

9.2.   Standard altimetry error model

9.2.1.   The errors in the simulated altitude measurements shall be assumed to be distributed as a Laplacian distribution with zero mean having probability density

$$p(e) = \frac{1}{2\lambda} \exp\left(-\frac{|e|}{\lambda} \right)$$

9.2.2.   The parameter λ required for the definition of the statistical distribution of altimeter error for each aircraft shall have one of two values, $\lambda1$ and $\lambda2$, which depend on the altitude layer of the encounter as follows:

Layer	1		2		3		4		5		6	
	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft
λ_1	10	35	11	38	13	43	17	58	22	72	28	91
λ_2	18	60	18	60	21	69	26	87	30	101	30	101

9.2.3.   For an aircraft equipped with ACAS the value of λ shall be $\lambda1$.

9.2.4.   For aircraft not equipped with ACAS, the value of λ shall be selected randomly using the following probabilities:

Layer	1	2	3	4	5	6
prob(λ_1)	0.391	0.320	0.345	0.610	0.610	0.610
prob(λ_2)	0.609	0.680	0.655	0.390	0.390	0.390

9.3.   Encounter Classes and Weights

9.3.1.   Aircraft address. Each aircraft shall be equally likely to have the higher aircraft address.

9.3.2.   Altitude layers. The relative weights of the altitude layers shall be as follows:

Layer	1	2	3	4	5	6
prob(layer)	0.13	0.25	0.32	0.22	0.07	0.01

9.3.3. Encounter classes

9.3.3.1. The encounters shall be classified according to whether the aircraft are level (L) or transitioning (T) at the beginning *(before tca)* and end (after *tca*) of the encounter window and whether or not the encounter is crossing, as follows:

Class	Aircraft No. 1		Aircraft No. 2		Crossing
	before tca	*after* tca	*before* tca	*after* tca	
1	L	L	T	T	yes
2	L	L	L	T	yes
3	L	L	T	L	yes
4	T	T	T	T	yes
5	L	T	T	T	yes
6	T	T	T	L	yes
7	L	T	L	T	yes
8	L	T	T	L	yes
9	T	L	T	L	yes
10	L	L	L	L	no
11	L	L	T	T	no
12	L	L	L	T	no
13	L	L	T	L	no
14	T	T	T	T	no
15	L	T	T	T	no
16	T	T	T	L	no
17	L	T	L	T	no
18	L	T	T	L	no
19	T	L	T	L	no

9.3.3.2. The relative weights of the encounter classes shall depend on layer as follows:

Class	for calculating risk ratio		for ATM compatibility	
	Layers 1-3	Layers 4-6	Layers 1-3	Layers 4-6
1	0.00502	0.00319	0.06789	0.07802
2	0.00030	0.00018	0.00408	0.00440
3	0.00049	0.00009	0.00664	0.00220
4	0.00355	0.0027	0.04798	0.06593
5	0.00059	0.00022	0.00791	0.00549
6	0.00074	0.00018	0.00995	0.00440
7	0.00002	0.00003	0.00026	0.00082
8	0.00006	0.00003	0.00077	0.00082
9	0.00006	0.00003	0.00077	0.00082
10	0.36846	0.10693	0.31801	0.09011
11	0.26939	0.41990	0.23252	0.35386
12	0.06476	0.02217	0.05590	0.01868
13	0.07127	0.22038	0.06151	0.18571
14	0.13219	0.08476	0.11409	0.07143
15	0.02759	0.02869	0.02374	0.02418
16	0.03578	0.06781	0.03088	0.05714
17	0.00296	0.00098	0.00255	0.00082
18	0.00503	0.00522	0.00434	0.00440
19	0.01183	0.03651	0.01021	0.03077

9.3.4. VMD *bins*

9.3.4.1. The VMD of each encounter shall be taken from one of ten VMD bins for the non-crossing encounter classes, and from one of nine or ten VMD bins for the crossing encounter classes. Each VMD bin shall have an extent of 100 ft for calculating risk ratio, or an extent of 200 ft for calculating compatibility with ATM. The maximum VMD shall be 1 000 ft for calculating risk ratio, and 2 000 ft otherwise.

9.3.4.2. For non-crossing encounter classes, the relative weights of the VMD bins shall be as follows:

vmd bin	for calculating risk ratio	for ATM compatibility
1	0.013	0.128
2	0.026	0.135
3	0.035	0.209
4	0.065	0.171
5	0.100	0.160
6	0.161	0.092
7	0.113	0.043
8	0.091	0.025
9	0.104	0.014
10	0.091	0.009

Note.— The weights for the VMD bins do not sum to 1.0. The weights specified are based on an analysis of encounters captured in ATC ground radar data. The missing proportion reflects the fact that the encounters captured included some with VMD exceeding the maximum VMD in the model.

9.3.4.3. For the crossing classes, the relative weights of the VMD bins shall be as follows:

vmd bin	for calculating risk ratio	for ATM compatibility
1	0	0.064
2	0.026	0.144
3	0.036	0.224
4	0.066	0.183
5	0.102	0.171
6	0.164	0.098
7	0.115	0.046
8	0.093	0.027
9	0.106	0.015
10	0.093	0.010

Note.— For the crossing classes, VMD must exceed 100 ft so that the encounter qualifies as a crossing encounter. Thus, for the calculation of risk ratio there is no VMD bin 1, and for calculations of the compatibility with ATM VMD bin 1 is limited to [100 ft, 200 ft].

9.4.   Characteristics of the Aircraft Trajectories in the Vertical Plane

9.4.1.   VMD. The VMD for each encounter shall be selected randomly from a distribution that is uniform in the interval covered by the appropriate VMD bin.

9.4.2. *Vertical rate*

9.4.2.1. For each aircraft in each encounter, either the vertical rate shall be constant ($\dot{z}$) or the vertical trajectory shall be constructed so that the vertical rate at $tca - 35$ s is $\dot{z}_1$ and the vertical rate at $tca + 5$ s is $\dot{z}_2$. Each vertical rate, $\dot{z}$, $\dot{z}_1$ or $\dot{z}_2$, shall be determined by first selecting randomly an interval within which it lies and then selecting the precise value from a distribution that is uniform over the interval selected.

9.4.2.2. The intervals within which the vertical rates lie shall depend on whether the aircraft is level that is, marked "L" in 9.4.1 or transitioning that is, marked in 9.4.1 and shall be as follows:

L	T
[240 ft/min, 400 ft/min]	[3200 ft/min, 6000 ft/min]
[80 ft/min, 240 ft/min]	[400 ft/min, 3200 ft/min]
[-80 ft/min, 80 ft/min]	[-400 ft/min, 400 ft/min]
[-240 ft/min, 80 ft/min]	[-3 200 ft/min, 400 ft/min]
[-400 ft/min, 240 ft/min]	[-6 000 ft/min, 3200 ft/min]

9.4.2.3. For aircraft that are level over the entire encounter window, the vertical rate $\dot{z}$ shall be constant. The probabilities for the intervals within which $\dot{z}$ lies shall be as follows:

$\dot{z}$ (ft/min)	prob($\dot{z}$)
[240 ft/min, 400 ft/min]	0.0382
[80 ft/min, 240 ft/min]	0.0989
[80 ft/min, 80 ft/min]	0.7040
[-240 ft/min, 80 ft/min]	0.1198
[-400 ft/min, 240 ft/min]	0.0391

9.4.2.4. For aircraft that are not level over the entire encounter window, the intervals for $\dot{z}1$ and $\dot{z}2$ shall be determined jointly by random selection using joint probabilities that depend on altitude layer and on whether the aircraft is transitioning at the beginning of the encounter window (Rate-to-Level), at the end of the encounter window (Level-to-Rate) or at both the beginning and the end (Rate-to-Rate). The joint probabilities for the vertical rate intervals shall be as follows:

for aircraft with Rate-to-Level trajectories in layers 1 to 3,

z_t Interval	joint probability of z_1 and z_t interval				
[240 ft/min, 400 ft/min]	0.0019	0.0169	0.0131	0.1554	0.0000
[80 ft/min, 240 ft/min]	0.0000	0.0187	0.0019	0.1086	0.0000
[-80 ft/min, 80 ft/min]	0.0037	0.1684	0.0094	0.1124	0.0075
[-240 ft/min, -80 ft/min]	0.0037	0.1461	0.0094	0.0243	0.0037
[-400 ft/min, -240 ft/min]	0.0000	0.1742	0.0094	0.0094	0.0019
	-6 000 ft/min	-3 200 ft/min	-400 ft/min	400 ft/min	3 200 ft/min	6 000 ft/min	z_1

for aircraft with Rate-to-Level trajectories in layers 4 to 6,

z_t Interval	joint probability of z_1 and z_t interval				
[240 ft/min, 400 ft/min]	0.0105	0.0035	0.0000	0.1010	0.0105
[80 ft/min, 240 ft/min]	0.0035	0.0418	0.0035	0.1776	0.0279
[-80 ft/min, 80 ft/min]	0.0279	0.1219	0.0000	0.2403	0.0139
[-240 ft/min, -80 ft/min]	0.0035	0.0767	0.0000	0.0188	0.0105
[-400 ft/min, -240 ft/min]	0.0105	0.0453	0.0035	0.0174	0.0000
	-6 000 ft/min	-3 200 ft/min	-400 ft/min	400 ft/min	3 200 ft/min	6 000 ft/min	z_1

for aircraft with Level-to-Rate trajectories in layers 1 to 3,

z_t Interval	joint probability of z_1 and z_t interval				
[3 200 ft/min, 6000 ft/min]	0.0000	0.0000	0.6000	0.0000	0.0000
[400 ft/min, 3200 ft/min]	0.0074	0.0273	0.0045	0.0720	0.1538
[-400 ft/min, 400 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0000
[-3 200 ft/min, 400 ft/min]	0.2978	0.2084	0.1365	0.0273	0.005
[-6 000 ft/min, -3 200 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0000
	-400 ft/min	-240 ft/min	-80 ft/min	80 ft/min	240 ft/min	400 ft/min	z_1

for aircraft with Level-to-Rate trajectories in layers 4 to 6,

z_t Interval	joint probability of z_1 and z_t interval				
[3 200 ft/min, 6 000 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0192
[400 ft/min, 3 200 ft/min]	0.0000	0.0000	0.0962	0.0577	0.1154
[400 ft/min, 400 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0000
[-3 200 ft/min, -400 ft/min]	0.1346	0.2692	0.2308	0.0577	0.0192
[-6 000 ft/min, -3 200 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0000
	-400 ft/min	-240 ft/min	-80 ft/min	80 ft/min	240 ft/min	400 ft/min	z_1

for aircraft with Rate-to-Rate trajectories in layers 1 to 3,

z_t Interval	joint probability of z_1 and z_t interval				
[3 200 ft/min, 6 000 ft/min]	0.0000	0.0000	0.0007	0.0095	0.0018
[400 ft/min, 3 200 ft/min]	0.0000	0.0018	0.0249	0.2882	0.0066
[-400 ft/min, 400 ft/min]	0.0000	0.0000	0.0000	0.0000	0.0000
[-3 200 ft/min, -400 ft/min]	0.0048	0.5970	0.0000	0.0029	0.0011
[-6 000 ft/min, -3 200 ft/min]	0.0000	0.0007	0.0000	0.0000	0.0000
	-6 000 ft/min	-3 200 ft/min	-400 ft/min	400 ft/min	3 200 ft/min	6 000 ft/min	z_1

for aircraft with Rate-to-Rate trajectories in layers 4 to 6,

$\dot{z}_2$ Interval	joint probability of $\dot{z}_1$ and $\dot{z}_2$ Interval				
(3 200 ft/min, 6 000 ft/min]	0.0014	0.0000	0.0028	0.0110	0.0069
[400 ft/min, 3 200 ft/min]	0.0028	0.0028	0.0179	0.4889	0.0523
[-400 ft/min, 400 ft/min]	0.0000	0.0000	0.0000	0.0000	0
[-3 200 ft/min, -400 ft/min]	0.0317	0.3029	0.0202	0.0152	0.0028
[-6 000 ft/min, -3 200 ft/min]	0.0110	0.0220	0.0014	0.0000	0

-6 000 ft/min   -3 200 ft/min   -400 ft/min   400 ft/min   3 200 ft/min   6 000 ft/min $\dot{z}_1$

9.4.2.5.   For a Rate-to-Rate track, if line $|\dot{z}_2 - \dot{z}_1| < 566$ ft/min then the track shall be constructed with a constant rate equal to $\dot{z}_1$.

9.4.3. Vertical acceleration

9.4.3.1.   Subject to 9.5.2.5 For aircraft that are not level over the entire encounter window, the rate shall be constant and equal to $\dot{z}_1$ over at least the interval [tca − 40 s, tca − 35 s] at the beginning of the encounter window, and shall be constant and equal to $\dot{z}_2$ over at least the interval [tca + 5 s, tca + 10 s] at the end of the encounter window. The vertical acceleration shall be constant in the intervening period.

9.4.3.2.   The vertical acceleration   shall be modelled as follows:

$$\ddot{z} = (A\dot{z}_2 - \dot{z}_1) + \varepsilon$$

where the parameter A is case-dependent as follows

	$A (s^{-1})$	
Case	Layers 1-3	Layers 4-6
Rate-to-Level	0.071	0.059
Level-to-Rate	0.089	0.075
Rate-to-Rate	0.083	0.072

and the error ε is selected randomly using the following probability density:

$$p(\varepsilon) = \frac{1}{2\mu}\exp\left(-\frac{|\varepsilon|}{\mu}\right)$$

Where

$$\mu = 0.3 \text{ ft s}^{-2}.$$

Note - The sign of the acceleration zدار is determined by $\dot{z}1$ and $\dot{z}2$. An error ε that reverses this sign must be rejected and the error reselected.

9.4.4. *Acceleration start time.* The acceleration start time shall be distributed uniformly in the time interval $[tca - 35\ s,\ tca - 5\ s]$ and shall be such that $\ddot{z}2$ is achieved no later than $tca + 5\ s$.

9.5. Characteristics of the Aircraft Trajectories in the horizontal Plane

9.5.1. *Horizontal Miss Distance*

9.5.1.1. For calculations of the effect of ACAS on the risk of collision, HMD shall be uniformly distributed in the range [0, 500 ft].

9.5.1.2. For calculations concerning the compatibility of ACAS with ATM, HMD shall be distributed so that the values of HMD have the following cumulative probabilities:

hmd (ft)	cumulative probability Layers 1-3	Layers 4-6	hmd (ft)	cumulative probability Layers 1-3	Layers 4-6
0	0.000	0.000	17013	0.999	0.868
1215	0.152	0.125	18228	1.000	0.897
2430	0.306	0.195	19443		0.916
3646	0.482	0.260	20659		0.927
4860	0.631	0.322	21874		0.939
6076	0.754	0.398	23089		0.946
7921	0.859	0.469	24304		0.952
8506	0.919	0.558	25520		0.965
9722	0.954	0.624	26735		0.983
10937	0.972	0.692	27950		0.993
12152	0.982	0.753	29165		0.996
13367	0.993	0.801	30381		0.999
14582	0.998	0.821	31596		1.000
15798	0.999	0.848			

9.5.2. *Approach angle.* The cumulative distribution for the horizontal approach angle shall be as follows: *approach cumulative probability approach cumulative probability angle (deg.) Layers 1-3 Layers 4-6 angle (deg.) Layers 1-3 Layers 4-6*

approach angle (deg.)	cumulative probability Layers 1-3	Layers 4-6	approach angle (deg.)	cumulative probability Layers 1-3	Layers 4-6
0	0.00	0.00	100	0.38	0.28
10	0.14	0.05	110	0.43	0.31
20	0.17	0.06	120	0.49	0.35
30	0.18	0.08	130	0.55	0.43
40	0.19	0.08	140	0.62	0.50
50	0.21	0.10	150	0.71	0.59

approach angle (deg.)	cumulative probability Layers 1-3	Layers 4-6	approach angle (deg.)	cumulative probability Layers 1-3	Layers 4-6
60	0.23	0.13	160	0.79	0.66
70	0.25	0.14	170	0.88	0.79
80	0.28	0.19	180	1.00	1.00
90	0.32	0.22			

9.5.3. *Aircraft speed.* The cumulative distribution for each aircraft's horizontal ground speed at closest approach shall be as follows:

ground speed (kt)	cumulative probability Layers 1-3	Layers 4-6	ground speed (kt)	cumulative probability Layers 1-3	Layers 4-6
45	0.000		325	0.977	0.528
50	0.005		350	0.988	0.602
75	0.024	0.000	375	0.997	0.692
100	0.139	0.005	400	0.998	0.813
125	0.314	0.034	425	0.999	0.883
150	0.486	0.064	450	1.000	0.940
175	0.616	0.116	475		0.972
200	0.700	0.171	500		0.987
225	0.758	0.211	525		0.993
250	0.821	0.294	550		0.998
275	0.895	0.361	575		0.999
300	0.949	0.427	600		1.000

9.5.4. *Horizontal manoeuvre probabilities.* For each aircraft in each encounter, the probability of a turn, the probability of a speed change given a turn, and the probability of a speed change given no turn shall be as follows:

Layer	Prob(turn)	Prob(speed change) given a turn	Prob(speed change) given no turn
1	0.31	0.20	0.5
2	0.29	0.20	0.25
3	0.22	0.10	0.15
4, 5, 6	0.16	0.05	0.10

9.5.4.1. Given a speed change, the probability of a speed increase shall be 0.5 and the probability of a speed decrease shall be 0.5.

9.5.5. *Turn extent.* The cumulative distribution for the extent of any turn shall be as follows:

Turn extent (deg.)	cumulative probability	
	Layers 1-3	Layers 4-6
15	0.00	0.00
30	0.43	0.58
60	0.75	0.90
90	0.88	0.97
120	0.95	0.99
150	0.98	1.00
180	0.99	
210	1.00	

9.5.5.1. The direction of the turn shall be random, with the probability of a left turn being 0.5 and the probability of a right turn being 0.5.

9.5.6. *Bank angle.* An aircraft's bank angle during a turn shall not be less than 15 degrees. The probability that it equals 15 degrees shall be 0.79 in layers 1-3 and 0.54 in layers 4-5. The cumulative distribution for larger bank angles shall be as follows:

Bank angle (deg.)	cumulative probability	
	Layers 1-3	Layers 4-6
15	0.79	0.54
25	0.96	0.82
35	0.99	0.98
50	1.00	1.00

9.5.7. *Turn end time.* The cumulative distribution for each aircraft's turn end time shall be as follows:

Turn end time	cumulative probability	
(seconds before tca)	Layers 1-3	Layers 4-6
0	0.42	0.28
5	0.64	0.65
10	0.77	0.76
15	0.86	0.85
20	0.92	0.94
25	0.98	0.99
30	1.00	1.00

9.5.8. *Speed change.* A constant acceleration or deceleration shall be randomly selected for each aircraft performing a speed change in a given encounter, and shall be applied for the duration of the encounter. Accelerations shall be uniformly distributed between 2 kt/s and 6 kt/s. Decelerations shall be uniformly distributed between 1 kt/s and 3 kt/s.

10. Compatibility with air traffic management (ATM)

10.1. An RA shall be considered a "nuisance" for the purposes of regulation 48 (1) unless, at some point in the encounter in the absence of ACAS, the horizontal separation and the vertical separation are simultaneously less than the following values :

	horizontal separation	vertical separation
above FL100	2.0 NM	750 ft
below FL100	1.2 NM	750 ft

10.2. Under the conditions of regulation 42, the collision avoidance logic shall be such that the number of RAs resulting in "deviations" greater than the values indicated shall not exceed the following proportions of the total number of RAs:.

	when own aircraft's vertical rate at the time the RA is first issued	
	is less than 400ft/min	exceeds 400ft/min
when the intruder is not ACAS equipped,		
for deviations ≥300 ft	0.15	0.23
for deviations ≥600 ft	0.04	0.13
for deviations ≥1 000 ft	0.01	0.07
when the intruder is equipped but does not respond,		
for deviations ≥300 ft	0.23	0.35
for deviations ≥600 ft	0.06	0.16
for deviations ≥1 000 ft	0.02	0.07
when the intruder is equipped and responds,		
for deviations ≥300 ft	0.11	0.23
for deviations ≥600 ft	0.02	0.12
for deviations ≥1 000 ft	0.01	0.06

(Reg. : 74, 78 and 79)

Automatic Dependent Surveillance -Broadcast

Figure 3 - 1: ADS-B/TIS-B system functional model
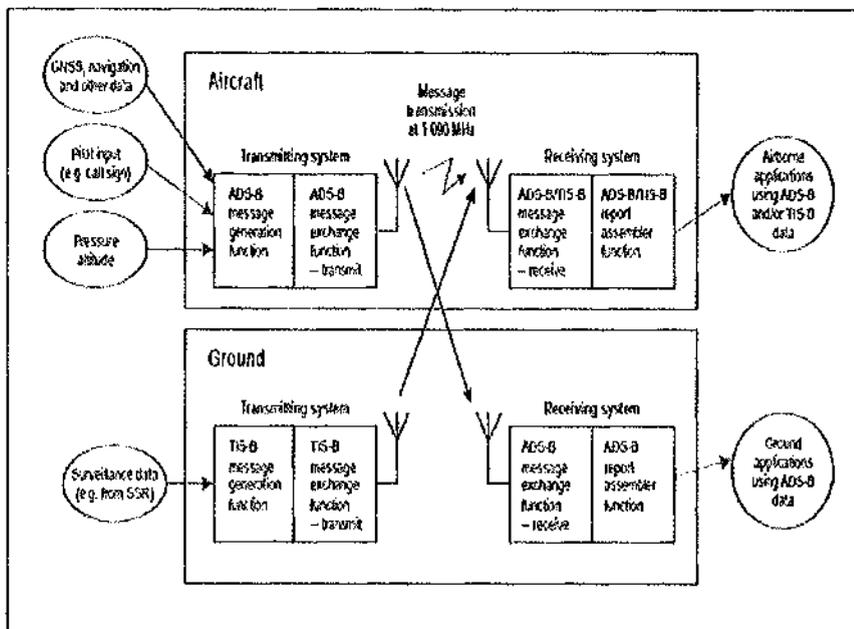
Table 3 -1: ADS-B Class A equipment characteristics

Equipment class	Minimum transmit power (at antenna terminal)	Maximum transmit power (at antenna terminal)	Airborne or surface	Minimum extended squitter message capability required (see Note 2)
A0 (Minimum)	18.5 dBW (see Note 1)	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status
A1 (Basic)	21 dBW	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status
A2 (Enhanced)	21 dBW	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status Target state and status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status
A3 (Extended)	23 dBW	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status Target state and status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status

Note 1.— See Schedule 1, 1.1.2.10.2 for restrictions on the use of this category of Mode S transponder.

Note 2.— The extended squitter messages applicable to Class A equipment are defined in the Technical Provisions for Mode S Services and Extended Squitter (ICAO Doc 9871).

Table 3 - 2: ADS-B Class B equipment characteristics-

Equipment class	Minimum transmit power (at antenna terminal)	Maximum transmit power (at antenna terminal)	Airborne or surface	Minimum extended squitter message capability required
B0 (Airborne)	18.5 dBW (see Note 1)	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status
B1 (Airborne)	21 dBW	27 dBW	Airborne	Airborne position Aircraft identification and category Airborne velocity Aircraft operational status Extended squitter aircraft status
			Surface	Surface position Aircraft identification and category Aircraft operational status Extended squitter aircraft status
B2 Low (Ground Vehicle)	8.5 dBW	< 18.5 dBW (see Note 2)	Surface	Surface position Aircraft identification and category Aircraft operational status
B2 (Ground Vehicle)	18.5 dBW	27 dBW (see Note 2)	Surface	Surface position Aircraft identification and category Aircraft operational status
B3 (Fixed Obstacle)	18.5 dBW	27 dBW (see Note 2)	Airborne (see Note 3)	Airborne position Aircraft identification and category Aircraft operational status

Note 1.— See Schedule 1, 1.1.2.10.2 for restrictions on the use of this category of Mode S transponder.

Note 2.— The appropriate ATS authority is expected to get the maximum power level permitted.

Note 3.— Fixed obstacles use the airborne ADS-B message formats since knowledge of their location is of primary interest to airborne aircraft

Table 3 - 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	Required extended squitter TIS-B message support
A0 (Basic VFR)	10 NM	–72 dBm	Standard	Airborne position Surface position Airborne velocity Aircraft identification and category Extended squitter airborne 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 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 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 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 regulation 64 (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 retriggering 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 regulation 64 (4).

Table 3 - 4: Mode S extended squitter airborne receiving system reporting requirements

Receiver Class	Minimum ADS-B reporting requirements	Minimum TIS reporting requirements
A0 (basic VFR)	ADS-B state vector report and ADS-B mode status report	TIS-B report and TIS-B management report
A1 (Basic IFR)	ADS-B state vector report and ADS-B mode status report and ADS-B air referenced velocity report (ARV)	TIS-B report and TIS-B management report
A2 (Enhanced IFR)	ADS-B state vector report and ADS-B mode status report and ARV report and ADS-B target state report	TIS-B report and TIS-B management report
A3 (Extended capability)	ADS-B state vector report and ADS-B mode status report and ARV report and ADS-B target state report	TIS-B report and TIS-B management report

SCHEDULE 4

FORM A

(Reg. 95)

Application for a Duplicate Document

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2. Original Document Number:..

   Date of First Issue............................. Place of First Issue:...
   (DD/MM/YY)

3. Reasons for applying for a duplicate

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4. Types of services for which the Document is required

Type of Air Navigation Services	Location	Type of Service (s)*(for ATS only)* *(the service to be provided within a particular airspace or controlled aerodrome designated to the provider by the Authority)*

5. Location at which the service is to be provided..

   I apply for the grant of a Duplicate Document based on the information provided in this form.

Signature...

Name (BLOCK LETTERS)..

Date:..Place...

MADE this 8th day of June, 2022.

ERIC MOTHIBI MOLALE,
Minister of Transport and Public Works.