

International Civil Aviation Organization



ICAO

**THE SIXTH MEETING OF MODE S AND DOWNLINKED
AIRCRAFT PARAMETERS WORKING GROUP
(MODE S AND DAPs WG/6)**

Bangkok, Thailand 28 – 30 March 2023

Agenda Item 6: Interrogator Code (IC) planning and coordination

**GUIDANCE MATERIAL FOR ASSIGNMENT OF INTERROGATOR CODES (IC) FOR
MLAT AND ADS-B**

(Presented by Singapore)

SUMMARY

During the Mode S DAPs WG/2, it was discussed whether interrogators that come with ADS-B need to be assigned with a distinct IC. Current practices suggested that II=0 can be used. However, the existing provision in ICAO documents is not clear to the reader and can be confusing. The Surveillance Panel Aeronautical Surveillance Working Group is working on revising the text in the SARPS and guidance material. The paper provides regular updates on the proposed changes.

1. INTRODUCTION

1.1 Mode S interrogators required an assignment of Interrogator Codes (IC). Such IC could either be Interrogator Identifier Codes (II Code) or Surveillance Identifier Codes (SI Code).

1.2 Mode S radars make use of ICs to reduce the need for aircraft to reply unnecessarily, by means of lock-out protocol. This is to help reduce frequency congestion. Due to this purpose of locking out in Mode S radar operations, radars with overlapping coverage do not share the same ICs. The assignment of ICs is to be coordinated within regions by centralised coordinating bodies (e.g. EUROCONTROL for Europe and ICAO APAC for the case of Asia-Pacific).

1.3 It was recalled that during Mode S DAPs WG/2, there was a discussion on such interrogators that come with ADS-B stations need to be assigned with a distinct IC.

1.4 The ICAO Surveillance Panel (SP) Aeronautical Surveillance Working Group (ASWG) has been informed in Sep 2019 on the lack of guidance material relating to this issue. This paper provides an update on the proposed changes to the SARPS and guidance material.

2. DISCUSSION

2.1 Annex 10 Volume IV is not clear on which values could be used in the IIS field of selective interrogations transmitted by interrogators not using Mode S all-call interrogations, not using the lockout command neither the multisite data-link protocols.

2.2 It is proposed to clarify the usage of IC code and IIS field. **The rationale for the clarifications is as follows:**

Lockout override should be permitted on any interrogator code (IC) and not limited to II=0, as the transponder will disregard the IC. Supplementary acquisition, which is limited by definition, should

also be allowed on any IC and not limited to II = 0. Systems that do not use Mode S-only all-call interrogations, lockout protocol, or multisite protocol should be able to use any IC and not be limited to II=0 if not assigned an IC. For example, multilateration systems may desire to use certain ICs for improved monitoring.

2.3 Enclosed is the latest paper from the **SP-AWSG/15** that addresses clarification on the use of II = 0, need for coordination for IC codes and other changes relating to Mode A/C/S all-call. The paragraphs below briefly describe some proposed changes.

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

3.1.2.5.2.1.2.3 II: Interrogator identifier. This 4-bit value shall define an interrogator identifier (II) code. These II codes shall be assigned to interrogators in the range from 0 to 15. ~~The II code value of 0 shall only be used for supplementary acquisition in conjunction with acquisition based on lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5).~~ When two **multiple** II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.

Note 1.— Limited data link activity including single segment Comm-A, uplink and downlink broadcast protocols and GICB extraction may be performed by both II codes.

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

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

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

a) If DI = 0, 1 or 7:

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

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

...

g) If DI = 3:

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

Note.— The SIS is intended to match the SI code used by the interrogator in the Mode S-only all-call interrogation (3.1.2.5.2.1). Interrogators that do not use Mode S-only all-call

interrogations, all-call lockout protocol, or multisite data-link protocol can use any IC in the SIS fields of their selective interrogations without coordination with neighbouring systems. The use of coordinated values differentiates interrogations transmitted by the different systems operating in the same area and facilitates the understanding of their respective contribution to the 1090 MHz environment.

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

...

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

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

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

2.6 Section 4 of Appendix M of Doc 9924 Aeronautical Surveillance Manual states that a Multilateration system is basically a passive system but it may use interrogations to achieve a certain level of performance. The document however does not mention the code to be used. The text is proposed to be improved as follows:

4. MLAT

4.1 Multilateration (MLAT) is basically a passive system but it systems may use interrogations to achieve a certain level of performance. Active WAM systems can be used in approach and en route environments. However, care must be exercised to limit the interrogations, primarily to minimize transponder occupancy. In such cases, selective interrogations transmitted by active systems have the dominant an important effect on the transponder availability because of the use of omnidirectional antennas. MLAT systems do not use Mode S all-call interrogations, lockout protocol, or multisite protocol. Therefore, they can use any IC in the IIS or SIS field of their selective interrogations, as it will not interfere with other interrogators using these protocols.

4.2 Significant levels of ACAS-interrogations may reduce the transponder availability to a point that roll-call retries start to become a significant factor. However, this will be mitigated by a dynamic active-WAM, which could abate roll-calls in the presence of ACAS passive reception of ACAS altitude reports.

3. EXPECTED TIMELINE FOR THE CHANGES

3.1 The proposed amendment in **Annex A** to this paper is discussed and endorsed by the Aeronautical Surveillance Working Group in Apr 2022. It will be presented to the Surveillance Panel in Sep 2023 before being accepted by the Air Navigation Council.

4. **ACKNOWLEDGEMENTS**

4.1 The author acknowledges the efforts of Mr Eric Portier from EUROCONTROL and Mr Jack Field from MITRE for working on the change proposal in Annex A.

5. **ACTION BY THE MEETING**

5.1 The meeting is invited to note the status of the amendments to the SARPS and guidance material for assignment of IC to interrogators.



International Civil Aviation Organization

WORKING PAPER

FOURTH MEETING OF THE SURVEILLANCE PANEL (SP/4)

**Fifteenth Meeting of the Aeronautical Surveillance Working Group
(SP4-ASWG/15)**

Web Meeting, from 4 April through 8 April 2022

SP4 Agenda item 3: Aeronautical surveillance systems

ASWG15 Agenda Item 6: Mode S and Extended Squitter

**II-SI Codes for Lockout Override, Supplementary Acquisition, and Non All-Call
Acquisition**

(Prepared by **Jack Field**)
(Presented by **Jack Field**)

SUMMARY

This working paper provides proposed changes to the SARPs and Doc 9924 related to lockout override and supplementary acquisition. The changes allow Mode S interrogators using lockout override with/without supplementary acquisition, as well as those not using all calls, to operate using any interrogator code.

This WP is prepared in response to ASWG/14-21.

ACTION

The meeting is invited to review, modify, as necessary, and agree on the proposed changes to Annex 10 Volume IV.

Note.- Action Item Number and WP Type.

Response: **B.** Draft CP Material or proposal for WG discussion and comment

Approved for Limited External Release Only to ICAO SP ASWG
Public Release Case Number 21-0210
© 2022 The MITRE Corporation.

1. INTRODUCTION

1.1 Multilateration

1.1.1 Some Mode S protocols, such as the lockout protocol and the multisite data-link protocols, use an Interrogator Code (IC) to differentiate interrogators in region of overlap.

1.1.2 Certain interrogators, including those used by multilateration systems, do not use the lockout protocol nor the multisite data-link and therefore do not need to be allocated a discrete IC to avoid interference in area of overlap.

1.1.3 The SARPs require Mode S interrogations to contain an Interrogator Identifier or Surveillance Identifier in the IIS or SIS fields (respectively) in surveillance interrogations (i.e., UF=4, 5) even if the lockout protocol and the multisite data-link protocols are not used. The IIS and SIS fields could be used to track the interrogations from different multilateration systems operating in the same area without generating interferences; therefore, there are benefits to be able to choose different ICs. The proposed changes in Section 2 allow interrogators that do not use lockout or multisite data-link protocols to use any IC, regardless of whether one has been assigned.

1.2 Acquisition without coordination

1.2.1 Some interrogators, especially mobile interrogators, are not assigned unique, discrete ICs. Due to the mobile nature of these interrogators, avoiding overlap with another interrogator using the same code cannot be guaranteed. Therefore, the techniques in 3.1.2.5.2.1.4 and 3.1.2.5.2.1.5 of lockout override and supplementary acquisition are used to acquire targets.

1.2.2 Lockout override is currently limited to $II=0$ by 3.1.2.5.2.1.4.3. When a transponder receives a Mode S-only all-call that is using lockout override, the IC in the interrogation will not be a factor – the transponder will process the reply regardless of lockout status to the received IC. The proposed changes in Section 2 include the allowance for an interrogator using lockout override to use any IC.

1.2.3 Supplementary acquisition of targets that cannot be acquired using lockout override is also currently limited to $II=0$. Supplementary acquisition is limited in duration and azimuth and therefore operation using any IC should also be permitted.

2. DISCUSSION

2.1 Proposed changes to Annex 10 V4 3.1.2.5 are detailed below. The proposed changes allow use of any IC when performing acquisition based on lockout override. The changes also allow the use of any IC when performing supplementary acquisition. This therefore permits use of $II=15$ for mobile interrogators (currently in use by certain mobile interrogators). Per the proposed changes, if no IC is assigned, the default IC for supplementary acquisition is $II=0$. There is also additional clean-up of 3.1.2.5.2.1.2 (Interrogator Code definition) and 3.1.2.5.2.1.3.1. Finally, there is the removal of requirements on selected interrogations, as they are not appropriate in the all-call section. Any necessary requirements on selected interrogations are discussed in Section 2.3 of this paper.

2.2 Changes to Annex 10 V4 3.1.2.1.5.1 (Intermode transactions) are being made as part of the consolidated paper related to changes to the RTCA/EUROCAE MOPS. No changes are needed here related to the Mode A/C/S all-call.

CHAPTER 3. SURVEILLANCE SYSTEMS

3.1 SECONDARY SURVEILLANCE RADAR (SSR) SYSTEM CHARACTERISTICS

3.1.2 Systems having Mode S capabilities

3.1.2.5 INTERMODE AND MODE S ALL-CALL TRANSACTIONS

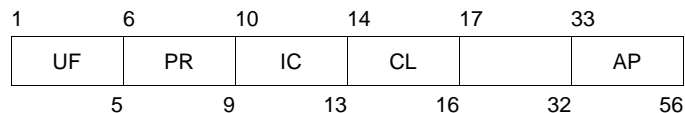
3.1.2.5.1 INTERMODE TRANSACTIONS

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

3.1.2.5.2 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 3.1.2.4.

3.1.2.5.2.1 Mode S-only all-call interrogation, uplink format 11



The format of this interrogation shall consist of these fields:

<i>Field</i>	<i>Reference</i>
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

3.1.2.5.2.1.1 *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 (3.1.2.5.4). 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.

3.1.2.5.2.1.2 *IC: Interrogator code.* This 4-bit (10-13) uplink field shall contain either the 4-bit interrogator identifier code (3.1.2.5.2.1.2.3) or the lower 4 bits of the 6-bit surveillance identifier code (3.1.2.5.2.1.2.4) depending on the value of the CL field (3.1.2.5.2.1.3).

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

3.1.2.5.2.1.2.2 *The use of multiple interrogator codes by one interrogator.* An interrogator 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 (Doc 9924).*

3.1.2.5.2.1.2.3 *II: Interrogator identifier.* This 4-bit value shall define an interrogator identifier (II) code. These II codes shall be assigned to interrogators in the range from 0 to 15. ~~The II code value of 0 shall only be used for supplementary acquisition in conjunction with acquisition based on lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5).~~ When ~~two multiple~~ II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.

Note 1.— *Limited data link activity including single segment Comm-A, uplink and downlink broadcast protocols and GICB extraction may be performed by both II codes.*

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

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

3.1.2.5.2.1.3 *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.

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

3.1.2.5.2.1.4 *Operation based on lockout override*

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

Note 2.— Lockout override is possible can be achieved using any interrogator code by setting the probability of reply (3.1.2.5.2.1.1) code in the range of 8 – 12.

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

3.1.2.5.2.1.4.1 *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.

3.1.2.5.2.1.4.2 **Recommendation.**— *Passive acquisition without using all-call interrogations should be used in the place of lockout override.*

Note.— The Aeronautical Surveillance Manual (Doc 9924) provides guidance on different passive acquisition methods.

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

~~UF = 4, 5, 20 or 21~~

PC = 0
DI = 7
HS = 0
LOS = 0 except as specified in 3.1.2.5.2.1.5
TMS = 0

~~3.1.2.5.2.1.4.4~~ An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit using H code 0 shall not attempt to extract an air initiated Comm B message announced by DR = 1 or 3.

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

3.1.2.5.2.1.5 Supplementary acquisition ~~using H equals 0~~

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

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

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

3.1.2.5.2.1.5.1 Lockout within a beam dwell

3.1.2.5.2.1.5.1.1 **Recommendation.**— When ~~H equals 0~~ lockout is used to supplement the acquisition method described in 3.1.2.5.2.1.4, all aircraft within the beam dwell of the aircraft being acquired should be commanded to lock out ~~to H 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 ~~H equals 0~~ all-call interrogations.

3.1.2.5.2.1.5.2 Duration of lockout

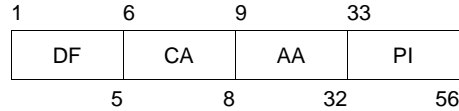
3.1.2.5.2.1.5.2.1 Interrogators performing supplementary acquisition ~~using H equals 0~~ shall perform acquisition by transmitting a lockout command for no more than two consecutive scans to each of the aircraft already acquired in the beam dwell containing the garble zone and shall not repeat it before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

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

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

3.1.2.5.2.2 All-call reply, downlink format 11



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

<i>Field</i>	<i>Reference</i>
DF downlink format	3.1.2.3.2.1.2
CA capability	3.1.2.5.2.2.1
AA address announced	3.1.2.5.2.2.2
PI parity/interrogator identifier	3.1.2.3.2.1.4

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

Coding

- 0 signifies Level 1 transponder (surveillance only), and no ability to set CA code 7 and either airborne or on the ground
- 1 reserved
- 2 reserved
- 3 reserved
- 4 signifies Level 2 or above transponder and ability to set CA code 7 and 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; and
- b) with automatic on-the-ground determination shall use CA code 4 when on the ground and 5 when airborne.

Data link capability reports (3.1.2.6.10.2.2) shall be available from aircraft installations that set CA code 4, 5, 6 or 7.

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

3.1.2.5.2.2.2 *AA: Address announced.* This 24-bit (9-32) downlink field shall contain the aircraft address which provides unambiguous identification of the aircraft.

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

- the interrogator is using an IC code different from zero; and
- the aircraft is located in an area where the interrogator is authorized to use lockout.

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

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).

3.1.2.5.4 *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 (3.1.2.5.2.1.1).

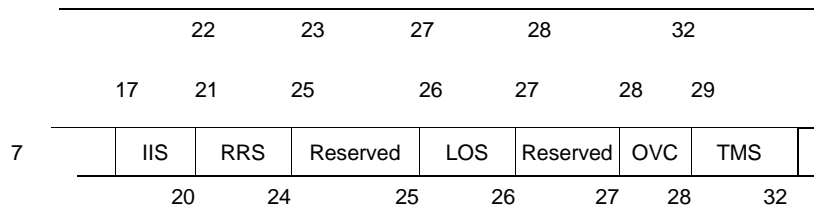
Note.— The random occurrence of replies makes it possible for the interrogator to acquire closely spaced aircraft, replies from which would otherwise synchronously garble each other.

2.3 Proposed changes to Annex 10 V4 3.1.2.6.1.4. Proposed changes make the IIS and SIS fields more generic and add notes to clarify that interrogators not using all-calls or lockout protocol for acquisition may use any IC in the IIS and SIS fields.

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

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

	DI CODE		SD FIELD STRUCTURE				
0	17	21	28	29			
	IIS	Reserved	OVC	Reserved			
	20	27	28	32			
1	17	21	23	26	27	29	
	IIS	MBS	MES	LOS	RSS	TMS	
	20	22	25	26	28	32	
2	17	21	24	27	29		
	Reserved	TCS	RCS	SAS	Reserved		
	20	23	26	28	32		
3	17	23	24	28	29		
	SIS	LSS	RRS	OVC	Reserved		



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

a) If DI = 0, 1 or 7:

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

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

b) If DI = 0:

bits 21-27 and 29-32 are not assigned.

c) If DI = 1:

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

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

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

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

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

- 0 signifies no request
- 1 signifies report Comm-B reservation status in UM

- 2 signifies report uplink ELM reservation status in UM
- 3 signifies report downlink ELM reservation status in UM.

d) If DI = 1 or 7:

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

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

e) If DI = 7:

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

Bits 25 and 27 are not assigned.

f) If DI = 2:

TCS, the 3-bit (21-23) type control subfield in SD shall control the extended squitter airborne and surface format types reported by the transponder and its response to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations. The following codes have been assigned:

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

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

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

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

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

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

SAS, the 2-bit (27-28) surface antenna subfield in SD shall control the selection of the transponder diversity antenna that is used for (1) the extended squitter when the transponder is reporting the

surface type formats, and (2) the acquisition squitter when the transponder is reporting the on-the-ground status. This subfield shall have no effect on the transponder diversity antenna selection when it is reporting the airborne status. The following codes have been assigned:

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

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

g) If DI = 3:

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

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

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

RRS, the 4-bit (24-27) reply request subfield in SD shall contain the BDS2 code of a requested GICB register.

Bits 29 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” 3.1.2.3.2.1.5) be overlaid upon the resulting reply to the interrogation in accordance with paragraph 3.1.2.6.11.2.5.

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

- a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 15 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1 f));
- b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 15 seconds;

- c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3 a);
- d) does not impact the air/ground state reported via the CA, FS and VS fields;
- e) discontinue broadcast of the extended squitter airborne message formats; and
- f) broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

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

- a) broadcast of the extended squitter surface formats, including the surface position message (3.1.2.8.6.4.3), the identification and category message (3.1.2.8.6.4.4), the aircraft operational status message (3.1.2.8.6.4.6) and the aircraft status message (3.1.2.8.6.4.6) for the next 60 seconds at the appropriate rates on the top antenna for aircraft systems having the antenna diversity capability, except if otherwise specified by SAS (3.1.2.6.1.4.1 f));
- b) inhibit replies to Mode A/C, Mode A/C/S all-call and Mode S-only all-call interrogations for the next 60 seconds;
- c) broadcast of acquisition squitters as per 3.1.2.8.5 using antenna as specified in 3.1.2.8.5.3 a);
- d) does not impact the air/ground state reported via the CA, FS and VS fields;
- e) discontinue broadcast of the extended squitter airborne message formats; and
- f) broadcast of the extended squitter surface formats at the rates according to the TRS subfield unless commanded to transmit at the rates set by the RCS subfield.

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

2.4 Proposed changes to Annex 10 V4 3.1.2.6.11.3. The proposed changes include restrictions on air-initiated Comm-B extraction by interrogators that have not been assigned an IC that is ensured to not overlap with another interrogator (previously referred to as “unique discrete”). This requirement was previously in 3.1.2.5.2.1.4.3, though worded differently.

3.1.2.6.11.3 *Air-initiated Comm-B*

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

The reply that delivers the message shall continue to contain code 1 in the DR field. After a Comm-B closeout has been accomplished, the message shall be cancelled and the DR code belonging to this message

immediately removed. If another air-initiated Comm-B message is waiting to be transmitted, the transponder shall set the DR code to 1, so that the reply contains the announcement of this next message.

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

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

2.5 Proposed changes to Annex 10 V4 3.1.2.11. The proposed changes add context to the lockout coordination section and change the section header from “ground interrogator” to “SSR Mode S interrogator” to be all inclusive.

3.1.2.11 ESSENTIAL SYSTEM CHARACTERISTICS OF THE ~~GROUND~~ MODE S INTERROGATOR

...

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

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

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

3.1.2.11.7 MOBILE INTERROGATORS

Recommendation.— *Mobile interrogators should 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.

2.6 Proposed changes to Doc 9924 Appendix H to allow lockout override on any IC and include details on supplementary acquisition. The proposed changes also include changing the term “adaptive technique” to “supplementary acquisition” for consistency with Annex 10 Volume IV. One instance of “adaptive” in the context of acquisition remains in section 1.6.3, as it is referring to stochastic acquisition, not supplementary acquisition used in conjunction with lockout override.

Appendix H

MODE S PROTOCOL CONSIDERATIONS

1. ACQUISITION AND LOCKOUT PROTOCOLS

1.1 General

1.4 Non-selective acquisition and lockout

1.4.1 Addressed interrogations containing $\text{II} = 0$ are not compatible with the Mode S subnetwork protocols. These protocols monitor discrete interrogations for II activity and use non-zero II codes for routing of downlink messages to intended ground addresses. Thus the use of non-selective acquisition (which is based on $\text{II} = 0$) cannot be used with an interrogator that is supporting the Mode S subnetwork. For this reason, $\text{II} = 0$ is no longer authorized for use in normal Mode S acquisition. $\text{II} = 0$ is now reserved for adaptive-supplementary acquisition in connection with stochastic/lockout override technique.

...

1.6 Stochastic acquisition

1.6.3 Implementation can include the following two modes:

- a) *Initial acquisition mode.* This mode is executed after a period of Mode S ground station inactivity. It consists of periodic Mode S-only all-call interrogations (4–6 or more per beam dwell) followed by a listening interval out to the range of interest. These are interspersed with scheduled Mode S intervals to permit discrete interrogation and lockout of Mode S addresses acquired on the previous scan. The minimum probability assignment used for this purpose is a site-dependent parameter chosen to match the Mode S traffic load handled by this site. The program for reacquisition begins at this lowest probability level and then moves to higher probability levels after several scans in order to reduce the overall acquisition time. Aircraft not acquired initially, as well as all-call garbling situations which occur unexpectedly during normal operation, are handled as described in the following paragraph; and
- b) *Adaptive acquisition mode.* Mode S replies received with uncorrectable errors during the all-call listening interval are grouped together if they correlate in range and azimuth. Groups formed of three or more replies per dwell are interpreted as evidence of an all-call synchronous garbling occurrence. A trial Mode S track is initiated at the approximate range and azimuth of the correlated replies. On the next scan, the ground station interrogates using a Mode S-only all-call with a specified reply probability of one half. With high probability, an ungarbled reply will be received from one of the two transponders in the garbling situation during the four or more interrogation opportunities possible during a beam dwell, thereby permitting discrete interrogation and lockout on the following scan. If acquisition is not successful, the trial track will be dropped since the continued garbling situation will lead to the initiation of a fresh trial track. Residual garbling caused by more than two aircraft in the initial garble set will also result in a new trial track. The last aircraft in the garbling set will be acquired by the normal all-call process in use at the site.

...

2. CONCEPTS FOR MODE S ACQUISITION WITHOUT LOCKOUT

2.1 Mode S acquisition using lockout override

2.1.1 Operational concept

2.1.1.1 Certain interrogators (e.g. mobile military interrogators) may not be in a position to have an assigned II or SI code in order to perform normal Mode S surveillance. A technique for performing Mode S acquisition using lockout override that does not require an assigned IC is described in this section.

2.1.1.2 An operational concept for Mode S acquisition using lockout override is defined as follows:

a) Routine aircraft surveillance is performed by these interrogators using Mode A/C, primary radar surveillance, or other means. For Mode A/C, monopulse processing must be used for having a lower interrogation rate. The channel time now available is used for Mode S acquisition;

b) On each scan, this type of interrogator schedules a number of Mode S-only all-call interrogations, followed by a listening interval appropriate for the operating range. These interrogations contain a lockout override code that commands Mode S transponders to respond to the interrogation regardless of their lockout state. The resulting synchronous garble is managed through the use of PR = 10 to 12 in the Mode S-only all-call interrogation. These codes command lockout override, together with a reduced probability of reply;

c) Every ungarbled Mode S all-call reply is processed and correlated in range and azimuth to the corresponding Mode A/C or primary radar track. The all-call reply contains the 24-bit aircraft address. This address is used in Mode S discretely addressed interrogations to obtain any supplemental information available from that aircraft. These discretely addressed interrogations ~~may contain an any IC equal to ZERO (0)~~ but do not contain any lockout commands. The discrete surveillance replies contain Mode C and Mode A codes which can also be used as further correlation criteria with a Mode A/C track. The interrogator has not modified in any way the lockout state of the aircraft as established by neighbouring Mode S interrogators using the multisite lockout protocols;

d) The 24-bit aircraft address is stored in the track file and is used for a subsequent update of this supplemental information;

e) The Mode S acquisition status of every aircraft in track is maintained in the track file, with one of the three following characteristics:

1) aircraft address acquired;

2) confirmation that the aircraft is not Mode S-equipped, since a prescribed number of interrogations has not resulted in an error-free reply reception or a Mode S preamble detection; or

3) Mode S acquisition in process; and

f) In order to minimize all-call FRUIT, all-call interrogations are only transmitted in beam dwells containing aircraft that are currently in the acquisition process.

2.1.2 Control of synchronous garble

2.1.2.1 The above operational concept for Mode S acquisition is based on the use of the lockout override feature. As the name implies, a Mode S-only all-call interrogation carries a code (PR = 8 to 12) that instructs the transponder to reply to this all-call regardless of its lockout state. Lockout override would be of limited use by itself since such transmissions would likely result in synchronously garbled Mode S all-call replies from aircraft close in slant range and within the same beam dwell as the aircraft of interest. The synchronous garble range for a Mode S all-call reply is 9.6 km (5.2 NM).

2.1.2.2 Mode S includes another feature known as “stochastic acquisition” that should be used with lockout override. Stochastic acquisition overcomes synchronous all-call garble by commanding the transponder (via a code in the all-call interrogation, PR = 10 to 12) to respond with a probability less than unity. Available probabilities are 1/4, 1/8 and 1/16. A reply probability of less than one reduces the total number of replies from a set of aircraft in garble range. This increases the likelihood of receiving a single ungarbled reply from an unacquired aircraft. Stochastic acquisition makes it possible to acquire a Mode S aircraft, even in relatively dense environments.

2.1.2.3 The performance of stochastic acquisition as a function of the number of aircraft in a garble zone and the probability used is presented in Table H-1. A summary of the performance to be expected with this technique is presented in Table H-2. The rows in Table H-2 indicate the number of aircraft in the garble zone defined by the beamwidth, and the 9.6 km (5.2 NM) garble zone for the Mode S all-call reply. It should be noted that having more than ten aircraft in the defined zone is quite rare. The columns indicate the maximum and average number of interrogations needed for 99 per cent probability of acquisition.

2.1.2.4 If an interrogator is unable to acquire all aircraft in a garble zone using stochastic acquisition, supplementary acquisition may be employed. Supplementary acquisition includes temporarily locking out all aircraft within the beam dwell of the unacquired aircraft. If the interrogator has been assigned an II or SI code, then that code may be used for supplementary acquisition. If the interrogator has not been assigned an II or SI code and coordination with other interrogators is not possible, $II = 0$ should be used. Lockout as part of supplementary acquisition may be used for no more than two consecutive scans to each aircraft already acquired in the beam dwell containing the garble zone and may not be repeated within 48 seconds. It is important to minimize the lockout time to reduce the probability of conflict with neighbouring interrogators using the same IC. Further details are in Section 2.1.5.

...

2.1.5 ~~Adaptive technique~~Supplementary acquisition for reduced acquisition time

2.1.5.1 Need for ~~an adaptive technique~~supplementary acquisition

The simulation results show that while rapid acquisition is provided by lockout override for most aircraft, it may take a long time to acquire all aircraft in a high density environment. Acquisition performance can, however, be improved by the use of supplementary acquisition via selective lockout.

2.1.5.2 Use of $II = 0$

2.1.5.2.1 The development of the Mode S subnetwork algorithms has greatly limited the utility of II code zero. The subnetwork communication protocols require the use of a non-zero II code in order to support downlink routing. Thus $II = 0$ will not be used when Mode S data link is used with the subnetwork services, even in areas of no overlapping sensor coverage.

2.1.5.2.2 Given that $II = 0$ will not be used in the most dense areas, it would seem that $II = 0$ could be eliminated for normal acquisition use without restricting Mode S operations.

2.1.5.3 ~~Adaptive~~Supplementary acquisition

2.1.5.3.1 For acquiring the last of the aircraft in a garble zone, ~~an adaptive technique~~supplementary acquisition using $II = 0$ operates as follows:

a) all of the acquired aircraft in the beam dwell of the garble zone containing the unacquired aircraft are discretely interrogated and locked out ~~to $II = 0$~~ ;

b) during the following scan, all-call interrogations are transmitted ~~using $II = 0$~~ , without lockout override, such that only the unacquired aircraft within the beam dwell will respond; and

c) transponders will unlock ~~to $II = 0$~~ , 18 seconds after the last lockout command.

2.1.5.3.2 The reduced garble density will lead to rapid acquisition of the unacquired aircraft, or a determination that it is not Mode S-equipped. Since lockout is used only temporarily and selectively, acquisition by neighbouring systems using the same IC will not be significantly impacted. only a minimum of coordination is required with neighbouring interrogators using lockout override to avoid conflict in the use of lockout to $II = 0$.

2.1.5.3.3 While supplementary acquisition is often performed using $II = 0$, it is possible using any II or SI code. If an interrogator has been assigned a non-unique IC (e.g., two mobile interrogators assigned the same IC), it may be possible to use that IC for supplementary acquisition. Interrogators that have not

been assigned an IC should use II = 0 for supplementary acquisition. Coordination is recommended to ensure that any interference between interrogators using the same IC is minimized.

2.7 Proposed changes to Doc 9924 Appendix M. The proposed changes are based in part on those agreed upon by the TSG in ASWG TSG WP 10-21R2. Incorrect references to Appendix F were noticed in Doc 9924. This proposal also changes those incorrect references to Appendix H. One additional incorrect reference to Appendix F was seen in Doc 9924 Appendix D Section 3.4.4. However, this section will also require updates with the changes to RTCA DO-181 and ED-73 and the correction should be made when Doc 9924 is updated in accordance with the RTCA/EUROCAE MOPS changes.

Appendix M

INTERFERENCE CONSIDERATIONS

...

2. THE USE OF STOCHASTIC LOCKOUT OVERRIDE

The Mode S-only all-call can provide the basis for acquisition of Mode S aircraft for interrogators that need the identity information available via Mode S but are not able to have an II code assigned for full Mode S operation. See Appendix ~~F-H~~ for details of this technique of acquisition.

...

3. MILITARY OPERATIONS

...

3.2 Mobile interrogators

...

3.2.5 ~~Typically, Mobile~~ Mode S ~~mobile~~ interrogators that have not been assigned an interrogator code should use II Code ZERO (0) in order to avoid conflicts with fixed Mode S interrogators. Appendix ~~F-H~~ contains more details on this subject.

...

4. MLAT

4.1 Multilateration (MLAT) ~~is basically a passive system but its systems~~ may use interrogations to achieve a certain level of performance. ~~Active WAM systems can be used in approach and en-route environments. H;~~ however, care must be exercised to limit ~~the~~ interrogations, primarily to minimize transponder occupancy. ~~In such cases, s~~Selective interrogations transmitted by active systems may have the dominant a significant impacteffect on ~~the~~ transponder availability because of the use of omnidirectional antennas. MLAT systems do not use Mode S all-call interrogations, lockout protocol, or multisite protocol. Therefore, they can use any IC in the IIS or SIS field of their selective interrogations without interfering with other interrogators using these protocols.

4.2 Significant levels of ~~ACAS~~ interrogations may reduce the transponder availability to a point that roll-call retries start to become a significant factor. However, this will be mitigated by a dynamic ~~active~~ WAM, which could abate roll-calls in the presence of ACAS-passive reception of altitude reports.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) review, modify, as necessary, and agree on the proposed changes to Annex 10 Volume IV.

APPENDIX A

PROPOSED AMENDMENT TO

ANNEX 10

AERONAUTICAL TELECOMMUNICATIONS

VOLUME IV — SURVEILLANCE AND COLLISION AVOIDANCE SYSTEMS

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

1. The text of the amendment is arranged to show deleted text with a line through it and new text highlighted with grey shading, as shown below:
 - a) ~~Text to be deleted is shown with a line through it.~~ text to be deleted
 - b) **New text to be inserted is highlighted with grey shading.** new text to be inserted
 - c) ~~Text to be deleted is shown with a line through it followed~~ **by the replacement text which is highlighted with grey shading.** new text to replace existing text
2. The source of the proposed amendment is the Surveillance Panel (SP).

INITIAL PROPOSAL 1

3.1 SECONDARY SURVEILLANCE RADAR (SSR) SYSTEM CHARACTERISTICS

...

3.1.2 Systems having Mode S capabilities

...

3.1.2.5 INTERMODE AND MODE S ALL-CALL TRANSACTIONS

...

3.1.2.5.2 *MODE S-ONLY ALL-CALL TRANSACTIONS*

...

3.1.2.5.2.1.2 *IC: Interrogator code.* This 4-bit (10-13) uplink field shall contain either the 4-bit interrogator identifier code (3.1.2.5.2.1.2.3) or the lower 4 bits of the 6-bit surveillance identifier code (3.1.2.5.2.1.2.4) depending on the value of the CL field (3.1.2.5.2.1.3).

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

3.1.2.5.2.1.2.2 *The use of multiple interrogator codes by one interrogator.* An interrogator 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 (Doc 9924).*

3.1.2.5.2.1.2.3 *II: Interrogator identifier.* This 4-bit value shall define an interrogator identifier (II) code. These II codes shall be assigned to interrogators in the range from 0 to 15. ~~The II code value of 0 shall only be used for supplementary acquisition in conjunction with acquisition based on lockout override (3.1.2.5.2.1.4 and 3.1.2.5.2.1.5).~~ When two multiple II codes are assigned to one interrogator only, one II code shall be used for full data link purposes.

Note 1.— *Limited data link activity including single segment Comm-A, uplink and downlink broadcast protocols and GICB extraction may be performed by both II codes.*

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

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

3.1.2.5.2.1.3 *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.

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

3.1.2.5.2.1.4 *Operation based on lockout override*

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

Note 2.— Lockout override is possible can be achieved using any interrogator code by setting the probability of reply (3.1.2.5.2.1.1) code in the range of 8 – 12.

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

3.1.2.5.2.1.4.1 *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.

3.1.2.5.2.1.4.2 **Recommendation.**— *Passive acquisition without using all-call interrogations should be used in the place of lockout override.*

Note.— The Aeronautical Surveillance Manual (Doc 9924) provides guidance on different passive acquisition methods.

~~3.1.2.5.2.1.4.3 *Field content for a selectively addressed interrogation used by an interrogator without an assigned interrogator code. An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit shall use the II code 0 to perform the selective interrogations.*~~

In this case, selectively addressed interrogations used in connection with acquisition using lockout override shall have interrogation field contents restricted as follows:

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

3.1.2.5.2.1.4.4 An interrogator that has not been assigned with a unique discrete interrogator code and is authorized to transmit using II code 0 shall not attempt to extract an air initiated Comm B message announced by DR = 1 or 3.

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

3.1.2.5.2.1.5 Supplementary acquisition using II equals 0

Note 1.— The acquisition technique defined in 3.1.2.5.2.1.4 provides rapid acquisition for most aircraft. Due to the probabilistic nature of the process acquiring aircraft with a reduced reply probability (3.1.2.5.2.1.4.1), it may take many interrogations to acquire the last aircraft of a large set of aircraft in the same beam dwell and near the same range (termed a local garble zone). Acquisition performance is greatly improved for the acquisition of these aircraft through the use of limited selective lockout, referred to here as supplementary acquisition 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 without lockout override with II=0. Only the aircraft not yet acquired and not yet locked-out will reply resulting in an easier acquisition. More guidance material can be found in Doc 9924.

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

3.1.2.5.2.1.5.1 Lockout within a beam dwell

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

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

3.1.2.5.2.1.5.2 Duration of lockout

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

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

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

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

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

- the interrogator is using an IC code different from zero; and
- the aircraft is located in an area where the interrogator is authorized to use lockout.

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

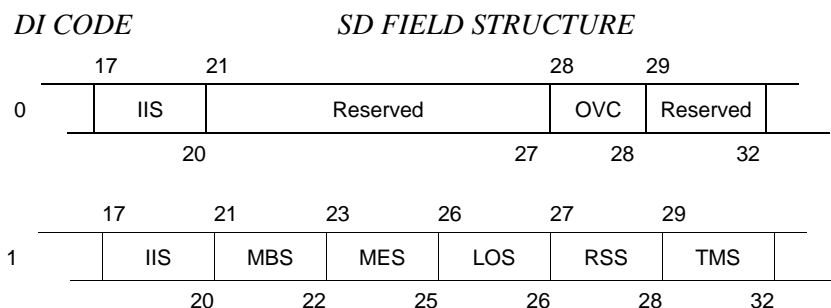
Note 2.— Regional IC allocation bodies may define rules limiting the use of selective interrogation and lockout protocol (e.g. no lockout in defined limited area, use of intermittent lockout in defined areas, and no lockout of aircraft not yet equipped with SI code capability).

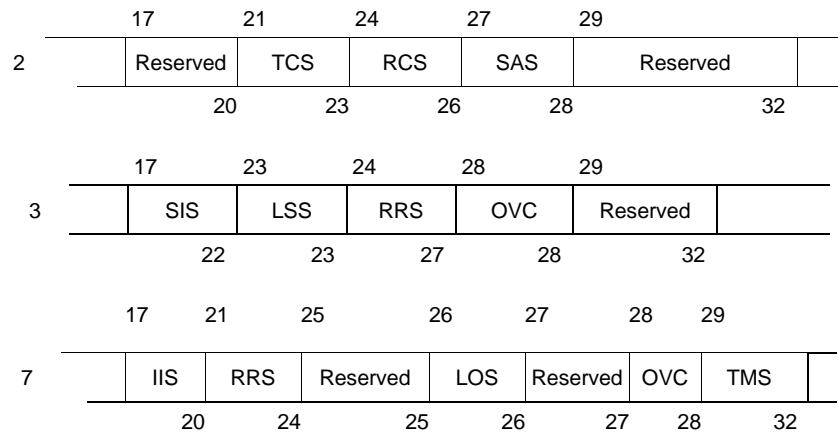
...
 3.1.2.6 ADDRESSED SURVEILLANCE AND STANDARD LENGTH COMMUNICATION TRANSACTIONS

...
 3.1.2.6.1 SURVEILLANCE, ALTITUDE REQUEST, UPLINK FORMAT 4

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

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





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

a) If DI = 0, 1 or 7:

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

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

...

g) If DI = 3:

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

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

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

RRS, the 4-bit (24-27) reply request subfield in SD shall contain the BDS2 code of a requested GICB register.

Bits 29 to 32 are not assigned.

...
3.1.2.6.11 STANDARD LENGTH COMMUNICATIONS PROTOCOLS

...
3.1.2.6.11.3 Air-initiated Comm-B

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

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

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

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

...
3.1.2.11 ESSENTIAL SYSTEM CHARACTERISTICS OF THE ~~GROUND~~MODE S INTERROGATOR

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

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

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

<i>Origin</i>	Rationale
SP/X	<p>Lockout override should be permitted on any interrogator code (IC) and not limited to II=0, as the transponder will disregard the IC. Supplementary acquisition, which is limited by definition, should also be allowed on any IC and not limited to II=0. Systems that do not use Mode S-only all-call interrogations, lockout protocol, or multisite protocol should be able to use any IC and not be limited to II=0 if not assigned an IC. For example, multilateration systems may desire to use certain ICs for improved monitoring.</p>

APPENDIX B

Proposed Change Proposal for: Annex 10 Volume IV, Chapter 3

Submit to: Rapporteur Aeronautical Surveillance Working Group

Page 1 of 1

1. Change No. ~~CPA 10V4/40XXXXXX~~

Date submitted: April 2022

Title: CP for modifying the use of interrogator codes

2. List of all relevant SP ASWG Working Papers: ASWG TSG WP 12-13, SP-ASWG13-WP11, ASWG TSG WP 13-20, SP4-ASWG14-WP15

3. Background: II and SI codes are used to identify the interrogator as part of multisite lockout, used to prevent aircraft that have already been detected from replying to all-call interrogations. Certain interrogators, such as airborne interrogators, use lockout override and supplementary acquisition to acquire all aircraft within their interrogation range. Systems that do not use Mode S-only all-call interrogations or lockout protocols are still required to enter an interrogator code in their directed interrogations. Interrogators using lockout override and supplementary acquisition, as well as those not using Mode S-only all-call interrogations or lockout protocols, are currently limited to using II=0.

4. Need for change: Allowing interrogators that do not use Mode S only all-calls or lockout protocols (such as multilateration systems) to enter an interrogator code other than II=0 in directed interrogations will allow for improved monitoring of interrogations. Allowing mobile interrogators to use an interrogator code other than II=0 for lockout override and supplementary acquisition will better support current and planned operations.

5. Change:

Modification of requirements in Annex 10 Volume IV section 3 in accordance with Initial Proposal 1.

6. Category: (confirmed by Rapporteur)

- 1) Addition - new material e.g. new GICB, MSP, or Broadcast.
- X 2) Update - technical change or correction to current document.
- 3) Useful - will enhance understanding of the document.
- 4) Cosmetic - needed to correct editorial error.

Submitted by: SP ASWG Technical Subgroup

Organisation: SP

Address: ICAO

APPENDIX C

- 1) COST BENEFIT STATEMENT,**
- 2) IMPACT ASSESSMENT, AND**
- 3) IMPLEMENTATION TASK LIST AND OUTLINE OF GUIDANCE MATERIAL**

1. COST AND BENEFIT STATEMENT FOR MODIFYING INTERROGATOR CODE USAGE

1.1 This cost/benefit statement concerns the proposal for amendment (PfA) modifying the way that interrogator codes are used by interrogators that do not use Mode S-only all-call interrogations or lockout protocols, in lockout override, and in supplementary acquisition.

1.2 The cost is negligible, as no changes are required to existing systems. Systems compliant with the current ICAO SARPs and guidance material will continue to be compliant with these proposed modifications.

1.3 The benefit to multilateration systems is the ability to assign discrete interrogator codes to different interrogators within nearby multilateration systems. This allows tracking of interrogations without generating additional interference.

1.4 The benefit to systems using lockout override and supplementary acquisition is the ability to interrogate on ICs other than II=0. Some nations restrict usage of II=0 and require mobile interrogators to use codes other than II=0. This is not currently allowed in ICAO Annex 10.

2. IMPACT ASSESSMENT AND IMPLEMENTATION PLAN



PART 1: IMPACT ASSESSMENT

1.1 What is the problem/opportunity that this proposal is designed to address?

Please include reference to Jobcard / ASBU / work programme item, as applicable

The development of updates to existing materials in light of operational experience, Interrogators that do not use Mode S-only all-call interrogations or lockout protocols (such as multilateration systems) and interrogators that use lockout override/supplementary acquisition (such as mobile interrogators) are currently limited to use of II=0 only as the interrogator code. Allowing these systems to use interrogator codes other than II=0 will permit operations consistent with current and planned usage, reduce potential interference, and improve performance monitoring. Job Card SP.008.02

1.2 What is the overall impact of this proposal on the strategic objectives of ICAO, namely:

	Positive / Negative / Negligible/None	Rationale: <i>Please provide an explanation for your choice and highlight any caveats or limitations in the selection</i>
Safety	Positive	Reduce potential interference between interrogators previously using II=0
Security	Negligible/None	
Environment	Negligible/None	
Efficiency	Positive	Allows multilateration systems to assign unique interrogator codes to interrogators facilitating improved MLAT performance monitoring

Note: In the following questions 'States' applies to the adoption and oversight of new SARPs. 'Industry' applies to the service provision and use, whether State owned or not (e.g. ANSPs, airlines aerodromes, meteorology, general aviation, etc). With respect to financial costs for States, it refers to the cost to develop, implement, maintain, and consider oversight issues associated with the proposed change. For Industry, it refers to the cost of implementing the change, where compliance is required by the State, which may translate in costs for equipage, human resources, training, documentation, aircraft modifications or upgrades, operations and airworthiness for example.

1.3 What is the overall impact on resources (financial, personnel, etc.) of this proposal for:

	Increase/decrease/negligible/unknown	Rationale: <i>Please provide an explanation for your choice and highlight any caveats or limitations in the selection</i>
States	Negligible/No impact	States compliant with the current ICAO SARPs and guidance material will continue to be compliant with these proposed modifications. States not compliant with the current ICAO materials but compliant with the proposed modifications will no longer need to file an exemption.
Industry	Negligible/None	Systems compliant with the current ICAO SARPs and guidance material will continue to be compliant with these proposed modifications.

1.4 In your opinion, do the benefits of this proposal justify the cost of implementing the proposal from the perspective of:

	Answer	Rationale: <i>Please provide an explanation for your choice and highlight any caveats or limitations in the selection</i>
States	Yes	No changes are required, as systems currently compliant will continue to be compliant. If changes are made, they would be enacted because those making the change would expect to see a benefit.

Industry	Yes	No changes are required, as systems currently compliant will continue to be compliant. If changes are made, they would be enacted because those making the change would expect to see a benefit.
----------	-----	--

PART 2: IMPLEMENTATION PLAN

To assist ICAO and States ensure this proposal will be effectively implemented please answer the following questions.

Note: The ANC recognizes that panel experts may feel limited in their ability to answer some or all of these questions, however, encourages the panels to provide their views. If still unsure, it is acceptable to leave one or more blank. The answers presented to the ICAO Council with the proposed amendment will be further developed by ICAO.

2.1 What supporting documentation is required for this proposed amendment?

Please include reference to any documents that require initial release/amendment e.g. ICAO Document or Circular name and number, industry specification, etc.

- ICAO Doc 9924

2.2 What other guidance, training and support activities do you recommend ICAO undertake to ensure the effective implementation of this proposed amendment?

Please include reference to any existing support/promotional programmes and whether it is required globally or regionally e.g. regional seminars, ikits, etc.

- None

2.3 What are the essential steps to be followed by a State in order to implement this proposed amendment?

Please include the major steps e.g. amendment of national legislation, change of oversight procedures, training of oversight personnel, required competencies, etc.

- If necessary/desired, modify interrogator code management plan to allow multilateration systems and mobile interrogators (or those not permanently assigned a unique interrogator code) to use interrogator codes other than II=0.

2.4 What is the timeframe needed to implement this proposal by:

	Answer	Rationale: <i>For the State, the timeframe is the length of time needed to implement in the national regulatory framework For industry, the timeframe is the length of time needed for industry to start implementing in their operations</i>
States	1 - 2 Years	States will implement changes when needed.
Industry	1 - 2 Years	Industry will implement changes when needed.

PART 3: AUDIT PLAN

Note: This section will be completed by ICAO prior to the presentation of any proposed changes to SARPs or PANS. The Panel Secretary will coordinate with the relevant experts in ICAO.

3.1 Does this proposal require an amendment of the USOAP CMA protocol questions to assess effective implementation by States?

Please include reference to existing PQs that may need amendment or description of any new PQs that may be required. State 'Not applicable' if no impact

No

3. IMPLEMENTATION TASK LIST AND OUTLINE OF GUIDANCE MATERIAL

1. IMPLEMENTATION TASK LIST

1.1 States that are already operating in a manner consistent with these changes will not require additional tasks for implementation. States that operate according to current requirements and do not wish to implement these changes will also not require tasks for implementation. No substantial involvement of States is expected to be required to implement the requirements of the amendment, as they are an expansion of the existing requirements. If States that operate according to current requirements that decide to implement these changes, States will need to consult with other relevant parties and establish procedures in order to maintain interoperability of the systems. For example, ensuring proper allocation of interrogator codes to mobile interrogators to limit confliction or assignment of interrogator codes to multilateration systems to monitor interrogation rates.

2. STANDARDIZATION PROCESS

2.1 Effective date: N/A

2.2 Applicability date: N/A

2.3 Embedded applicability date (s): N/A

3. SUPPORTING DOCUMENTATION

3.1 ICAO documentation

Title	Type (PANS/TI/Manual/Circ)	Planned publication date
<i>Aeronautical Surveillance Manual (Doc 9924).</i>	Manual	

3.2 External documentation

Title	External Organization	Publication date
N/A		

**4. UNIVERSAL SAFETY OVERSIGHT AUDIT
PROGRAMME (USOAP)**

4.1 Protocol question required (y/n) - No

No changes to the Protocol Questions are expected to be needed.

APPENDIX D

PROPOSED UPDATE TO

DOC 9924

SURVEILLANCE AND COLLISION AVOIDANCE SYSTEMS

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

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

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

2. The source of the proposed amendment is the Surveillance Panel (SP).

INITIAL PROPOSAL 1

Appendix H MODE S PROTOCOL CONSIDERATIONS

1. ACQUISITION AND LOCKOUT PROTOCOLS

1.1 General

1.4 Non-selective acquisition and lockout

1.4.1 Addressed interrogations containing $\text{II} = 0$ are not compatible with the Mode S subnetwork protocols. These protocols monitor discrete interrogations for II activity and use non-zero II codes for routing of downlink messages to intended ground addresses. Thus the use of non-selective acquisition (which is based on $\text{II} = 0$) cannot be used with an interrogator that is supporting the Mode S subnetwork. For this reason, $\text{II} = 0$ is no longer authorized for use in normal Mode S acquisition. $\text{II} = 0$ is now reserved for adaptive-supplementary acquisition in connection with stochastic/lockout override technique.

...

2. CONCEPTS FOR MODE S ACQUISITION WITHOUT LOCKOUT

2.1 Mode S acquisition using lockout override

2.1.1 Operational concept

2.1.1.1 Certain interrogators (e.g. mobile military interrogators) may not be in a position to have an assigned II or SI code in order to perform normal Mode S surveillance. A technique for performing Mode S acquisition using lockout override that does not require an assigned IC is described in this section.

2.1.1.2 An operational concept for Mode S acquisition using lockout override is defined as follows:

a) Routine aircraft surveillance is performed by these interrogators using Mode A/C, primary radar surveillance, or other means. For Mode A/C, monopulse processing must be used for having a lower interrogation rate. The channel time now available is used for Mode S acquisition;

b) On each scan, this type of interrogator schedules a number of Mode S-only all-call interrogations, followed by a listening interval appropriate for the operating range. These interrogations contain a lockout override code that commands Mode S transponders to respond to the interrogation regardless of their lockout state. The resulting synchronous garble is managed through the use of PR = 10 to 12 in the Mode S-only all-call interrogation. These codes command lockout override, together with a reduced probability of reply;

c) Every ungarbled Mode S all-call reply is processed and correlated in range and azimuth to the corresponding Mode A/C or primary radar track. The all-call reply contains the 24-bit aircraft address. This address is used in Mode S discretely addressed interrogations to obtain any supplemental information available from that aircraft. These discretely addressed interrogations may contain any IC equal to ZERO (0) but do not contain any lockout commands. The discrete surveillance replies contain Mode C and Mode A codes which can also be used as further correlation criteria with a Mode A/C track. The interrogator has not modified in any way the lockout state of the aircraft as established by neighbouring Mode S interrogators using the multisite lockout protocols;

d) The 24-bit aircraft address is stored in the track file and is used for a subsequent update of this supplemental information;

e) The Mode S acquisition status of every aircraft in track is maintained in the track file, with one of the three following characteristics:

- 1) aircraft address acquired;
- 2) confirmation that the aircraft is not Mode S-equipped, since a prescribed number of interrogations has not resulted in an error-free reply reception or a Mode S preamble detection; or
- 3) Mode S acquisition in process; and

f) In order to minimize all-call FRUIT, all-call interrogations are only transmitted in beam dwells containing aircraft that are currently in the acquisition process.

2.1.2 Control of synchronous garble

2.1.2.1 The above operational concept for Mode S acquisition is based on the use of the lockout override feature. As the name implies, a Mode S-only all-call interrogation carries a code (PR = 8 to 12) that instructs the transponder to reply to this all-call regardless of its lockout state. Lockout override would be of limited use by itself since such transmissions would likely result in synchronously garbled Mode S all-call replies from aircraft close in slant range and within the same beam dwell as the aircraft of interest. The synchronous garble range for a Mode S all-call reply is 9.6 km (5.2 NM).

2.1.2.2 Mode S includes another feature known as “stochastic acquisition” that should be used with lockout override. Stochastic acquisition overcomes synchronous all-call garble by commanding the transponder (via a code in the all-call interrogation, PR = 10 to 12) to respond with a probability less than unity. Available probabilities are 1/4, 1/8 and 1/16. A reply probability of less than one reduces the total number of replies from a set of aircraft in garble range. This increases the likelihood of receiving a single ungarbled reply from an unacquired aircraft. Stochastic acquisition makes it possible to acquire a Mode S aircraft, even in relatively dense environments.

2.1.2.3 The performance of stochastic acquisition as a function of the number of aircraft in a garble zone and the probability used is presented in Table H-1. A summary of the performance to be expected with this technique is presented in Table H-2. The rows in Table H-2 indicate the number of aircraft in the garble zone defined by the beamwidth, and the 9.6 km (5.2 NM) garble zone for the Mode S all-call reply. It should be noted that having more than ten aircraft in the defined zone is quite rare. The columns indicate the maximum and average number of interrogations needed for 99 per cent probability of acquisition.

2.1.2.4 If an interrogator is unable to acquire all aircraft in a garble zone using stochastic acquisition, supplementary acquisition may be employed. Supplementary acquisition includes temporarily locking out all aircraft within the beam dwell of the unacquired aircraft. If the interrogator has been assigned an II or SI code, then that code may be used for supplementary acquisition. If the interrogator has not been assigned an II or SI code and coordination with other interrogators is not possible, II = 0 should be used. Lockout as part of supplementary acquisition may be used for no more than two consecutive scans to each aircraft already acquired in the beam dwell containing the garble zone and may not be repeated within 48 seconds. It is important to minimize the lockout time to reduce the probability of conflict with neighbouring interrogators using the same IC. Further details are in Section 2.1.5.

...

2.1.5 ~~Adaptive technique~~ Supplementary acquisition for reduced acquisition time

2.1.5.1 ~~Need for an adaptive technique~~ supplementary acquisition

The simulation results show that while rapid acquisition is provided by lockout override for most aircraft, it may take a long time to acquire all aircraft in a high density environment. Acquisition performance can, however, be improved by the use of supplementary acquisition via selective lockout.

2.1.5.2 Use of II = 0

2.1.5.2.1 The development of the Mode S subnetwork algorithms has greatly limited the utility of II code zero. The subnetwork communication protocols require the use of a non-zero II code in order to support downlink routing. Thus II = 0 will not be used when Mode S data link is used with the subnetwork services, even in areas of no overlapping sensor coverage.

2.1.5.2.2 Given that II = 0 will not be used in the most dense areas, it would seem that II = 0 could be eliminated for normal acquisition use without restricting Mode S operations.

2.1.5.3 ~~Adaptive~~ Supplementary acquisition

2.1.5.3.1 For acquiring the last of the aircraft in a garble zone, supplementary acquisition ~~an adaptive technique using II = 0~~ operates as follows:

a) all of the acquired aircraft in the beam dwell of the garble zone containing the unacquired aircraft are discretely interrogated and locked out ~~to II = 0~~;

b) during the following scan, all-call interrogations are transmitted ~~using II = 0~~, without lockout override, such that only the unacquired aircraft within the beam dwell will respond; and

c) transponders will unlock ~~to II = 0~~, 18 seconds after the last lockout command.

2.1.5.3.2 The reduced garble density will lead to rapid acquisition of the unacquired aircraft, or a determination that it is not Mode S-equipped. Since lockout is used only temporarily and selectively, acquisition by neighbouring systems using the same IC will not be significantly impacted. ~~only a minimum of coordination is required with neighbouring interrogators using lockout override to avoid conflict in the use of lockout to II = 0.~~

2.1.5.3.3 While ~~this adaptive technique~~ supplementary acquisition is often performed using II=0, it is possible using any II or SI code. If an interrogator has been assigned a non-unique IC (e.g., two mobile interrogators assigned the same IC), it may be possible to use that IC for supplementary acquisition. Interrogators that have not been assigned an IC and cannot ensure they will not overlap with another interrogator using the same IC should use II=0 for supplementary acquisition. Coordination is recommended to ensure that any interference between interrogators using the same IC is minimized.

...

Appendix M

INTERFERENCE CONSIDERATIONS

...

2. THE USE OF STOCHASTIC LOCKOUT OVERRIDE

The Mode S-only all-call can provide the basis for acquisition of Mode S aircraft for interrogators that need the identity information available via Mode S but are not able to have an II code assigned for full Mode S operation. See Appendix ~~FH~~ for details of this technique of acquisition.

...

3. MILITARY OPERATIONS

...

3.2 Mobile interrogators

...

3.2.5 Typically, Mobile Mode S mobile interrogators that have not been assigned an interrogator code should use II Code ZERO (0) in order to avoid conflicts with fixed Mode S interrogators. Appendix FH contains more details on this subject.

...

4. MLAT

4.1 Multilateration (MLAT) is basically a passive system but its systems may use interrogations to achieve a certain level of performance. Active WAM systems can be used in approach and en route environments. However, care must be exercised to limit the interrogations, primarily to minimize transponder occupancy. In such cases, selective interrogations transmitted by active systems may have the dominant a significant impact effect on the transponder availability because of the use of omnidirectional antennas. MLAT systems do not use Mode S all-call interrogations, lockout protocol, or multisite protocol. Therefore, they can use any interrogator code in the IIS or SIS field of their selective interrogations without interfering with other interrogators using these protocols.

4.2 Significant levels of ACAS interrogations may reduce the transponder availability to a point that roll-call retries start to become a significant factor. However, this will be mitigated by a dynamic active WAM, which could abate roll-calls in the presence of ACAS passive reception of altitude reports.

APPENDIX E

Proposed Change Proposal for: Doc 9924 Appendices H and M

Submit to: Rapporteur Aeronautical Surveillance Working Group

Page 1 of 1

1. Change No. ~~CP ASM/27XXXXXX~~

Date submitted: April 2022

Title: CP for modifying the use of interrogator codes

2. List of all relevant SP ASWG Working Papers: ASWG TSG WP 12-13, SP-ASWG13-WP11, ASWG TSG WP 13-20, SP4-ASWG14-WP15

3. Background: II and SI codes are used to identify the interrogator as part of multisite lockout, used to prevent aircraft that have already been detected from replying to all-call interrogations. Certain interrogators, such as airborne interrogators, use lockout override and supplementary acquisition to acquire all aircraft within their interrogation range. Systems that do not use Mode S-only all-call interrogations or lockout protocols are still required to enter an interrogator code in their directed interrogations. Interrogators using lockout override and supplementary acquisition, as well as those not using Mode S-only all-call interrogations or lockout protocols, are currently limited to using II=0.

4. Need for change: Allowing interrogators that do not use Mode S only all-calls or lockout protocols (such as multilateration systems) to enter an interrogator code other than II=0 in directed interrogations will allow for improved monitoring of interrogations. Allowing mobile interrogators to use an interrogator code other than II=0 for lockout override and supplementary acquisition will better support current and planned operations.

5. Change:

Modification of Doc 9924 Appendices H and M in accordance with Initial Proposal 1.

6. Category: (confirmed by Rapporteur)

- 1) Addition - new material e.g. new GICB, MSP, or Broadcast.
- X 2) Update - technical change or correction to current document.
- 3) Useful - will enhance understanding of the document.
- 4) Cosmetic - needed to correct editorial error.

Submitted by: SP ASWG Technical Subgroup

Organisation: SP

Address: ICAO

APPENDIX F

1) COST BENEFIT STATEMENT,

1. COST AND BENEFIT STATEMENT FOR MODIFYING INTERROGATOR CODE USAGE

1.1 This cost/benefit statement concerns the change proposal for modifying the way that interrogator codes are used by interrogators that do not use Mode S-only all-call interrogations or lockout protocols, in lockout override, and in supplementary acquisition.

1.2 The cost is negligible, as no changes are required to existing systems. Systems compliant with the current ICAO SARPs and guidance material will continue to be compliant with these proposed modifications.

1.3 The benefit to multilateration systems is the ability to assign discrete interrogator codes to different interrogators within nearby multilateration systems. This allows tracking of interrogations without generating additional interference.

1.4 The benefit to systems using lockout override and supplementary acquisition is the ability to interrogate on ICs other than II=0. Some nations restrict usage of II=0 and require mobile interrogators to use codes other than II=0. This is not currently allowed in ICAO Annex 10.