International Civil Aviation Organization

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

Bangkok, Thailand, 7 – 10 May 2024

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

CHANGE PROPOSAL TO AERONAUTICAL SURVEILLANCE MANUAL (DOC 9924)

(Presented by Co-chair)

SUMMARY

The fifth meeting of the Surveillance Panel took place in September 2023 and endorsed change proposal to Aeronautical Surveillance Manual (Doc 9924). This paper highlights the changes that are of interest to SURICG.

1. INTRODUCTION

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

1.2 This paper highlights the changes to Doc 9924 that are of interest to the SURICG.

2. DISCUSSION

Summary Of Changes

2.1 The fifth meeting of the SP endorsed the change proposal as attached in **Annex A**. The proposal contains changes to several sections of Doc 9924. The changes include:

a) Clarification Related to P1 control and P1 sum timing in the context of Improved Interrogation Side Lobe Suppression (I^2SLS) functionality

b) Guidance material related to baseline power limits

c) Guidance material on the use of reduced performance devices

d) Modifying the use of interrogator codes

e) Further clarify II/SI code allocation in Doc 9924 APP H and J

Highlights (Modifying The Use Of Interrogator Codes)

2.2 It was recalled that during Mode S DAPs WG/2, there was a discussion on such interrogators that come with ADS-B stations need to be assigned with a distinct IC. It was not clear from the ICAO

materials then which values could be used although EUROCONTROL has been using II = 0. The Surveillance Panel (SP) Aeronautical Surveillance Working Group (ASWG) therefore worked on the amendments to address, *inter alia*, the ICs that can be assigned for interrogators not using Mode S all-call interrogations, lockout command and the multisite data-link protocols.

2.3 The usage of IC code and IIS field were clarified in Annex 10 Vol IV. The rationale for the clarifications is as follows:
Lockout override should be permitted on any interrogator code (IC) and not limited to II=0, as the transponder will disregard the IC. Supplementary acquisition, which is limited by definition, should also be allowed on any IC and not limited to II = 0. Systems that do not use Mode S-only all-call interrogations, lockout protocol, or multisite protocol should be able to use any IC and not be limited to II=0 if not assigned an IC. For example, multilateration systems may desire to use certain ICs for improved monitoring.

2.4 Section 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 was proposed to be improved as follows:

> **4. MLAT**
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> 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.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 have ~~the dominant~~an 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.

Highlights (Further Clarify II/SI Code Allocation in Doc 9924 App H And J)

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

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

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

2.8 The II/SI code operation is a specific mode of operation that allows interrogators operating on SI code to acquire Mode S II-only transponders on the matching II code. It was necessary to use that

mode of operation in ICAO EUR Region to allocate SI codes to radars before all transponders are SI code capable. This mode of operation has been made mandatory in EU regulation. It is included in the European Mode S radar specification (EMS 4.0).

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

2.10 While the existing Doc 9924 provides a general guidance that radars with overlapping coverages must not have the same II or SI codes, it lacks details on planning for co-existence of II and SI codes.

2.11 Changes were therefore proposed to:

a) clarify and elaborate the acquisition and detection of Mode S II-only (non-SI capable) transponders by Mode S II/SI capable interrogators as well as the acquisition and detection of Mode S II/SI capable transponders by Mode S II-only interrogators as currently described in paragraphs 1.2.5 – 1.2.11 of **Appendix H** to the Aeronautical Surveillance Manual (Doc. 9924).

b) introduces the planning criteria in **Appendix J** for co-existence of II and SI codes under the environment where there are non-SI capable transponders still in operations.

Acknowledgements

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

3 ACTION BY THE MEETING

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

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APPENDIX A

PROPOSAL FOR AMENDMENT (PFA) TO AERONAUTICAL SURVEILLANCE MANUAL (DOC 9924), CONCERNING

1. Change Proposal to add Clarification Related to P1 control and P1 sum timing in the context of I2SLS functionality (CP ASM/29)

2. Change Proposal to insert a guidance material related to Baseline Power limits (CP ASM/25)

3. Change Proposal to introduce a guidance material on the use of reduced performance devices (CP ASM/26)

4. Change Proposal for modifying the use of interrogator codes (CP ASM/27)

5. Change Proposal to further clarify II/SI code allocation in Doc 9924 APP H and J (CP ASM/28)

PROPOSED AMENDMENT TO

AERONAUTICAL SURVEILLANCE MANUAL (DOC 9924)

NOTES ON THE PRESENTATION OF THE PROPOSED AMENDMENT

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

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

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

INITIAL PROPOSAL 1

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APPENDIX D. SSR SYSTEM TECHNIQUES

Appendix D
SSR SYSTEM TECHNIQUES

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2. GROUND STATION INSTALLATION

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2.5 Additional techniques for combatting reflections

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2.5.2 I^2SLS

2.5.2.1 It should be noted that this technique will cause suppression periods in transponders over a wide azimuth, which can degrade the probability of transponder reply to interrogations from other SSR stations. Therefore, it must not be used unless absolutely necessary.

2.5.2.2 This technique exploits the characteristic of transponders that requires them not to reply for 35 ±10 microseconds after suppression by a pair of pulses conforming to Annex 10, Volume IV, Chapter 3. Since transponders will not reply to interrogations falling within a suppression period, it is necessary to provide for additional suppression in areas where reflections occur. This can be achieved by radiating P_1 in addition to P_2 on the "control" pattern normally used for SLS. Suppression is then assisted throughout the side-lobe region. If separate RF path are used for P1sum (∑) and P1control (**Ω**), care must be taken to ensure that both the P1sum (∑) and P1control (**Ω**) pulses comply with the pulse characteristic and timing described in Annex 10, Volume IV chapter 3.1.1.4. Note that only one P1 pulse is defined in Annex 10, Volume IV chapter 3.1.1.4 so the P1 requirements are applicable to both P1sum (∑) and P1control (**Ω**). For systems having Mode-S capability, the interval timing described in Annex 10, Volume IV chapter 3.1.2.1.5.2.4 are applicable. Experience has shown that using Mode S P1-P2 timing tolerance is recommended even for Mode A/C only systems.

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Origin	**Rationale for Initial Proposal 1**
SP/5	In the ICAO material only one P1 pulse is defined whether it is used for interrogation or control. In the current electronics of the radar observed, the P1 pulse is generated by one source but travel different path to become P1sum(Σ) and P1control(**Ω**). So already at the output of the RF source a difference in timing between P1Σ and P1**Ω** can be observed. Clarification in Doc 9924 added to address this in case the I^2SLS functionality is used.

INITIAL PROPOSAL 2

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2.8 Additional techniques for combatting reflections

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2.8 Pulse extraction

Ground station receiver**s** may encounter transponders transmitting a baseline signal at or below 50dB below the pulse peak power before, between, and after the transmission of pulses of a reply or a squitter**.** An example of such transmission is given on figure x.

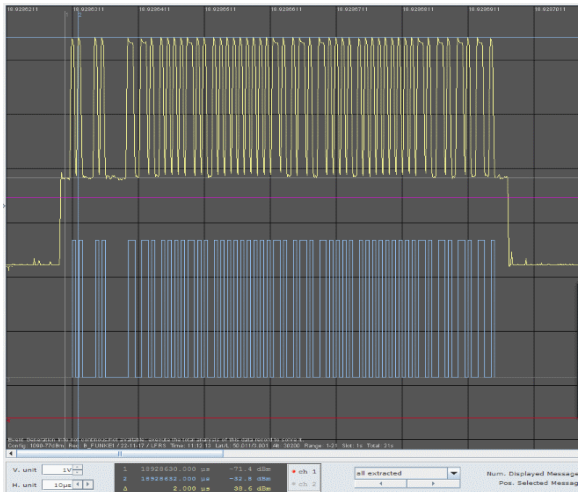

Figure D-10 –Example of a Mode S reply with high RF output transmitted between before and after pulses

The pulse extraction process should be designed in such a way that it does not trigger pulse detection on the baseline signal transmitted by transponders while transmitting a reply.

More particularly the ground station systems should be able to retrigger on leading edges happening after the detection of a first leading edge generated by the start of the baseline transmission otherwise the system could detect a too long pulse that could result in the rejection of Mode S replies. Similarly, systems using statistical analysis of all received samples should take care of a possible large set of samples around the RF output level transmitted between pulses.

Receivers should also implement the necessary processing to avoid detection of a false Mode A/C reply using the pulse detected on the leading edge generated by the start of the CW transmission and a pulse (e.g. D4 pulse) within the Mode A/C reply.

Origin: SP/5	*Rationale:* Problems of interoperability have been discovered due to the transmission of a CW signal at a too high level around pulses of Mode A/C and Mode S messages. An explicit requirement will be added in SARPS to limit the RF transmission around the pulse transmitted on 1090 MHz during a reply but since this protection will not be sufficient for systems using high sensitivity receivers, additional guideline was produced, which will be included in Doc 9924.

INITIAL PROPOSAL 3

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Appendix S

GUIDANCE ON 1 090 MHZ SPECTRUM ISSUES AND PROPER MANAGEMENT OF 24-BIT AIRCRAFT ADDRESSES ASSOCIATED WITH UNMANNED AIRCRAFT (UA) AND REDUCED CAPABILITY 1090 MHZ ADS-B EQUIPMENT

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4. REDUCED CAPABILITY 1090 MHZ ADS-B EQUIPMENT

4.1 Definition and technical characteristics

4.1.1 By reduced capability 1090 MHz ADS-B equipment it is understood ADS-B extended squitter transmitters or transceivers employing downlink format DF=18 squitter, portable/easy to install devices with reduced power (less than minimum transponder required power), being marketed for use by General Aviation in light/ultra-light aircraft not equipped with transponders. These devices are often self-contained and have no interface with other on-board CNS systems. More information can be found in RTCA DO-260C and EUROCAE ED-102B.

4.1.2 The device is expected to contain a 1090 MHz ADS-B transmitter combined either with a commercial off-the-shelf or an aviation compliant/certified GNSS receiver.

4.1.3 For reduced capability 1090 MHz ADS-B equipment to provide a useful level of surveillance capability, it is expected as a minimum to transmit ICAO 24-bit aircraft address, Aircraft Position, Aircraft Altitude (Barometric and/or Geometric), and relevant ADS-B quality indicators. Such devices may provide additional capability such as, but not limited to, Airborne Velocity, Aircraft Identification, and Aircraft Category. All messages are anticipated to conform to the appropriate sections either in the locally applicable or most recent version of RTCA DO-260 and EUROCAE ED-102.

4.1.4 Reduced capability 1090 MHz ADS-B equipment may comprise of commercial off the shelf items such as software defined radios, GNSS receiver chipsets and, where applicable, altitude transducers, which may not be confirmed as performing to an applicable standard, but are acceptable on the basis that relevant quality indicators reported by the device are set to an appropriate value. Such low quality or no quality indicators will mean the emitted data would not be usable by the air traffic control for the provision of a separation service or by some traffic avoidance systems fitted to aircraft. Those ADS-B reports may however be used for other purposes, e.g., improved situational awareness subject to a proper safety analysis.

4.1.5 Reduced capability 1090 MHz ADS-B equipment is expected to have the facility to programme or re-programme the ICAO 24-bit address and possibly Aircraft Identification.

4.1.6 Depending on their level of sophistication, the following capabilities are expected:

a) transmit-only device, or
b) transmit/receive device with visual and/or audible alerts.

4.1.7 Reduced capability 1090 MHz ADS-B equipment should not be used at the same time with transponders that emit 1090 MHz Extended Squitter downlink format DF= 17 in the aircraft.

4.2 Implementation considerations

4.2.1 Where reduced capability 1090 MHz ADS-B equipment is approved for use, it is recommended that States/Authorities put in place a system to ensure that these devices conform with the local applicable standards.

4.2.2 States should indicate in their aviation information publications the following:

a) the environment/airspace in which the devices may be used,
b) technical characteristics required for the devices,
c) the types of aircraft that may use such devices, and

d) any other applicable advice relating to the setting and operation of the devices.

4.2.3 Processes should be put in place to manage the allocation of ICAO 24-bit aircraft addresses in order to prevent random, arbitrary, duplicate and other impermissible addresses by the users of reduced capability 1090 MHz ADS-B equipment.

4.2.4 It is not intended that the installation and use of reduced capability 1090 MHz ADS-B equipment replace any requirement for the installation and use of a fully functioning transponder in any airspace or under flight rules requiring such a transponder. The use of reduced capability 1090 MHz ADS-B equipment may be subject to additional national or regional regulations.

4.2.5 The quality indicators reported by the devices may indicate low quality or no quality values when received by ground ATS surveillance systems and ADS-B IN capable aircraft receivers. It is therefore recommended that such receiving systems apply appropriate quality filtering processing to prevent unintended use of the data relevant to the system/service being supported.

4.3 Manufacturer considerations

4.3.1 When seeking for approval of reduced capability 1090 MHz ADS-B equipment, manufacturers are expected to provide Authorities proper documentation demonstrating, as a minimum, that the equipment does not affect the safety of persons, or the safe operation of the aircraft by causing interference to other radio users, and the data transmitted is correct and appropriate for the device. The signal-in-space of the device should comply with the requirements in ICAO Annex 10, Volume IV except for power output.

4.3.2 It is recognized that reduced capability 1090 MHz ADS-B equipment may not be subject to routine maintenance and tests throughout their lifecycle in the same way that conventional avionics equipment is. Therefore, it is highly recommended that the manufacturer seeking approval for their device provide a simple form of built-in confidence checking, failure detection and indication.

4.3.3 As a minimum, the following items should be available in the operating manual of the device:

a) the requirement and instructions for setting up the ICAO 24-bit address and Aircraft Identification for the aircraft that the device is being carried on,
b) instructions on how to deactivate the device transmitter when it is used only in receive mode in an aircraft equipped with an operating transponder,
c) instructions for mounting the device antenna(s) if applicable, so that they do not compromise the operation of other CNS systems and cause harm to human body,
d) a warning that it is ultimately the responsibility of the pilot to ensure that the device causes no harmful interference to other on-board systems,
e) instructions for carrying out a pre-flight cross-check of the reported altitude against the aircraft altimeter if appropriately equipped.

Origin: SP/5	*Rationale:* Due to possible numerous utilizations of reduced capability 1090 MHz ADS-B equipment there exist a risk of 1090 MHz congestion, unwanted interferences, and possible depletion of the 24-bit aircraft address block allocated to a State. Additional guidance is proposed to ensure the correct use of these devices.

INITIAL PROPOSAL 4

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Appendix H

MODE S PROTOCOL CONSIDERATIONS

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1.4 Non-selective acquisition and lockout

1.4.1 Addressed interrogations containing 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 II = 0) cannot be used with an interrogator that is supporting the Mode S subnetwork. For this reason, II = 0 is no longer authorized for use in normal Mode S acquisition. II = 0 is now reserved for ~~adaptive~~ supplementary acquisition in connection with stochastic/lockout override technique.

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

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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;

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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.

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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.

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2.1.5.3 *~~Adaptive~~ Supplementar 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 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.

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Appendix M

Interference considerations

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3.2.4 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 H contains more details on this subject.

Note.— Some States do not allow mobile interrogator use of II Code ZERO (0), therefore a discrete interrogator code is locally coordinated and assigned.

4. MLAT

4.1 Multilateration (MLAT) systems ~~is basically a passive system but it~~ 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 effect~~ a significant impact 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.

Origin:	*Rationale:*
SP/5	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.

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INITIAL PROPOSAL 5

EXPLANATION OF TERMS

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Designated Operational Coverage. The volume of airspace, within which a Mode S facility is needed operationally and the use of specified interrogator codes is protected.

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II/SI code operation. A mechanism that enables Mode S ground stations operating on SI code to acquire Mode S II-only aircraft transponders on the “matching II code” and to track them. This mechanism is used by the Mode S ground stations operating on II code or SI code not to lock Mode S II-only aircraft transponders on II code in order to ensure the acquisition of these aircraft by Mode S ground stations using the II code or matching SI codes.

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

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

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Mode S II/SI capable interrogator. A Mode S ground station that complies with the provisions of Annex 10, including Amendment 73 or higher (1998 or later), i.e., it supports II and SI code protocols.

Mode S II-only interrogator. A Mode S ground station that complies with the provisions of Annex 10 Volume IV up to and including Amendment 71 (1996) and therefore does not support SI code.

Mode S II-only transponder. A transponder that complies with the provisions of Annex 10 Volume IV up to and including Amendment 71 (1996) and therefore does not support SI code.

Mode S II/SI capable transponder. A Mode S transponder that complies with the provisions of Annex 10 Volume IV Amendment 73 or higher (1998 or later), i.e., it supports II and SI code protocols.

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ACRONYMS AND ABBREVIATIONS

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DOC Designated operational coverage

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Appendix H

MODE S PROTOCOL CONSIDERATIONS

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1.1.1 In order to selectively interrogate a Mode S-equipped aircraft, the *Mode S ground station*[1] must know the aircraft's 24-bit ~~Mode S~~ *Aircraft address*[2] and approximate position. To acquire the addresses of Mode S equipped aircraft, each Mode S ground station transmits all-call interrogations. A Mode S-equipped aircraft will respond to such an interrogation with its unique *24-bit Aircraft address*. On the first or second antenna scan after receiving the initial all-call replies, the Mode S ground station will begin to selectively ~~discretely~~ interrogate the aircraft and command the lockout condition for the Interrogator Code[3] (IC) in use by the ground station. The benefit of waiting until the second scan before lockout is that it allows a better estimate of aircraft velocity, which gives a more accurate estimate of the time that the aircraft will be in the main beam on the next scan. Accurate time estimate can not only improve the success rate of selective interrogation, but also optimize the efficiency of beam-dwell time. After acquisition, the aircraft's 24-bit *Aircraft address* will be added to the Mode S ground station's file of acquired aircraft.

1.1.2 Once acquired, the Mode S-equipped aircraft ~~must~~should be locked out from replying (instructed not to respond) to subsequent Mode S all-call interrogations in order to minimize all-call synchronous garbling. This lockout condition is controlled by the Mode S ground station through Mode S selectively addressed interrogations. If for any reason an aircraft ceases to receive selectively-addressed interrogations containing a lockout command for a period of approximately 18 seconds (corresponding to a few antenna scans), any existing lockout will lapse so that the aircraft may be reacquired by normal Mode S acquisition.

1.1.2.1 Alternatively, in special cases such as described in paragraphs 1.2.5 to 1.2.12 below, the aircraft equipped with Mode S II-only transponders[4] should be intermittently locked out or not be locked out.

[1] ***Mode S ground station.*** Ground equipment that interrogates Mode A/C and Mode S transponders using intermode and Mode S interrogations. A monopulse capable antenna and a rotary joint providing at least two channels for sum and difference processing are a pre-requisite for Mode S operation.

[2] ***Aircraft address.*** A unique combination of twenty-four bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance. The 24-bit aircraft address is described in Annex 10, Volume III, Chapter 9 – *AIRCRAFT ADDRESSING SYSTEM*

[3] ***Interrogator Code (IC)***. A code used to identify an interrogator in Mode S protocols. It may be either an Interrogator Identifier (II) or Surveillance Identifier (SI) code.

[4] A Mode S II-only transponder complies with the provisions of Annex 10, up to and including Amendment 71 (1996)

1.1.3 The interrogation used by the Mode S ground station to elicit all-call replies depends upon the acquisition technique in effect at that site.

1.1.4 Operational experience has shown that many Mode S transponders interpret a Mode S interrogation that is received near the minimum triggering level (MTL) or is corrupted by multipath as a Mode A/C/S all-call interrogation. The result is an unwanted all-call reply with an associated interrogator identifier (II) code equal to zero. These unwanted replies result in a significant increase in the rate of all-call replies around busy terminals. Unwanted all-call replies can be eliminated by locking out all Mode S aircraft under surveillance to II=0 in addition to the radar's assigned interrogator code. This dual lockout can be accomplished by locking out to each interrogator code on alternate scans.

1.2 Multisite acquisition and lockout

1.2.1 Multisite acquisition is carried out by using the Mode S-only all-call interrogation uplink format (UF) = 11 (Annex 10, Volume IV, Chapter 2.1.2.1). The IC of the interrogating site is contained in the interrogation. Two types of ICs are defined:

a) the II code is used for multisite surveillance and data link coordination. II codes of 1 to 15 are valid (an II code of ZERO (0) is interpreted as non-selective); and

b) the SI code is used only for multisite surveillance and the limited data link functions (It shall not be used with the multisite uplink or down link ELM protocols). ~~identified~~ SI codes of 1 to 63 are valid. SI code ZERO (0) is not used.

1.2.2 The transponder replies to this interrogation if it is not in a state of lockout to that specific IC. The Mode S II-only transponder has a total of 16 independent lockout timers to maintain the lockout state requested by the ground stations (i.e. 16 II lockout timers). The Mode S II/SI capable[5] transponder has a total of 79 independent lockout timers to maintain the lockout state requested by the ground stations (i.e. 16 II and 63 SI lockout timers).

1.2.3 Matching II and SI codes.

1.2.3.1 An SI code transmitted in a Mode S-only all-call interrogation by a Mode S II/SI capable interrogator[6] is composed of the IC field and the CL field (Uplink format (UF) 11). The binary format of a Mode S-only all-call interrogation (UF 11) is provided in Figure H-1.

UF11 (01011)	PR (4 bits)	IC (4 bits)	CL (3 bits)	(16 bits)	AP (24 bits)
		Interrogator Code	Code Label (000 for II codes)	Set to "zeroes"	Address is set to 24 "ones" Parity for the first 32 bit is overlaid

Figure H-1. Binary format of Uplink Format 11

The CL field is encoded (in 3 bits binary format):

000	signifies that IC field contains the II code
001	signifies that IC field contains SI codes 1 to 15
010	signifies that IC field contains SI codes 16 to 31
011	signifies that IC field contains SI codes 32 to 47
100	signifies that IC field contains SI codes 48 to 63

Figure H-2. Encoding of CL field in UF 11

The IC field is encoded (in 4 bits binary format) equivalent to 0 to 15 in decimal format.

A "matching" SI code is an SI code whose binary format in the IC field is the same as the binary format in the IC field of the II code. Each Mode S II code has four "matching" SI codes.

A "matching" II code is an II code whose binary format in the IC field is the same as the binary format in the IC field of the SI code. Each Mode S SI code has one "matching" II code.

[5] A Mode S II/SI capable transponder complies with the provisions of Annex 10, Amendment 73 or higher (1998 or later)

[6] A Mode S II/SI capable interrogator complies with the provisions of Annex 10, including Amendment 73 or higher (1998 or later)

1.2.3.2 Mode S II/SI capable ~~Only~~ transponders ~~complying with at least Amendment 73 (or higher) of Annex 10~~ will decode the CL field in order to determine whether the content of the IC field is an II code (Field CL = 000) or an SI code (field CL = 001 – 100). A Mode S II-only capable t~~T~~ransponder ~~which have not been upgraded to handle SI codes will, by default~~ considers the content of the IC field as being an II code value since it cannot decode the CL field. In the following example: the interrogator transmits a Mode S-only all-call interrogation on SI 37, the CL field contains the code 011 (consistent with the SI codes 32 to 47) and the IC field contains the code 0101 (decimal 5). The SI code that has been transmitted is 32 + 5 = 37.

UF11 (01011)	PR (4 bits)	IC (4 bits)	CL (3 bits)	(16 bits)	AP (24 bits)
		0101 (decimal 5)	Code Label 011	Set to "zeroes"	Address is set to 24 "ones" Parity for the first 32 bit is overlaid

Figure H-3. Example of all-call interrogation on SI 37

The Mode S II-only capable transponder decodes the interrogation received with SI code 37 as being the II code 5 since the CL field cannot be decoded. This is, through the field IC, the "matching" II code.

1.2.3.3`Therefore, if the CL field is not equal to zero (meaning that the IC field contains an SI code), the Mode S II-only ~~non-upgraded~~ transponders will encode the parity sequence of the reply using the "matching" II code rather than the SI code contained in the interrogation.

The table of matching II – SI codes is as follows:

II Code	Matching SI code Field CL = 001 SI codes 01 - 15	Matching SI_code Field CL = 010 SI codes 16 - 31	Matching SI_Code Field CL = 011 SI codes 32 - 47	Matching SI_Code Field CL = 100 SI codes 48 - 63
00		16	32	48
01	01	17	33	49
02	02	18	34	50
03	03	19	35	51
04	04	20	36	52
05	05	21	37	53
06	06	22	38	54
07	07	23	39	55
08	08	24	40	56
09	09	25	41	57
10	10	26	42	58
11	11	27	43	59
12	12	28	44	60
13	13	29	45	61
14	14	30	46	62
15	15	31	47	63

1.2.3.4 If the Mode S II/SI capable interrogator transmits a Mode S-only all-call interrogation with the II code (where the field CL is set to 000 (zero)) both the Mode S II/SI capable transponder and the Mode S II-only capable transponder can correctly decode the II code contained in the Mode S-only all-call interrogation (UF11) and reply (DF11) with that II code.

1.2.4 Mode S II-only transponders, when being interrogated with an SI code, reply with the "matching" II code since it cannot decode the CL field in the Mode S-only all-call interrogation.

1.2.4.1 The interrogator, which will receive Mode S-only all-call replies encoded with the "matching" II code will normally reject these replies. The consequence is that Mode S II-only transponders which have not been upgraded to handle SI codes will not be detected by the interrogator operating with an SI code.

1.2.5 The following techniques enables the acquisition and detection of non-SI capable transponders for the transition period.

Note.- The techniques as clarified in paragraph 1.2.6 – 1.2.11 provide means to acquire and detect non-SI capable transponders that must be implemented during the transition period until all of the Mode S aircraft are equipped with II/SI capable transponder. These techniques define the II/SI code operation mechanism. The Mode S II/SI capable interrogators implementing these techniques support the use of II/SI code operation.

1.2.6 The interrogator that supports the use of II/SI code operation, when operating with an SI code, must be configurable by the user to accept Mode S-only all-call replies for which the "matching" II code has been used to encode the parity sequence.

1.2.6.1 While normally a Mode S II/SI capable interrogator operating with an SI code would reject the replies from Mode S II-only transponders, a Mode S II/SI interrogator that supports the use of II/SI code operation is configurable to acquire these transponders on the “matching” II code during the transition phase to full Mode S SI implementation.

1.2.7 The target which has sent such replies must be considered as equipped with a non-SI capable transponder, even if the content of Register 10_{16} states that the transponder has the SI capability.

1.2.7.1 The “target” is the transponder that has sent, in response to the Mode S-only all-call interrogation from the Mode S II/SI capable interrogator operating with an SI code, a reply on the “matching” II code. Some Mode S transponders may report they are Mode S II/SI capable (in Bit 35 of Register 10_{16}) whereas they are not Mode S II/SI capable.

1.2.8 The interrogator that supports the use of II/SI code operation, if operating with an SI code, must be configurable by the user to interrogate targets equipped with non-SI capable transponders using the Mode S-selective protocols foreseen for II code operation. The II code to be used must be the "matching" II code.

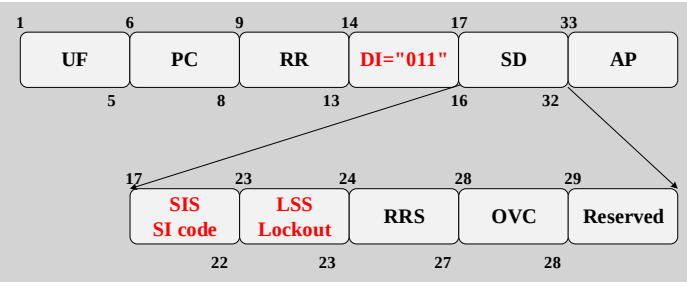
1.2.8.1 The II/SI code operation mechanism, that is to be implemented during the transition period toward full implementation of Mode S II/SI capable transponders allows selective interrogation of a Mode S II-only capable transponder using the “matching” II code.

1.2.9 The interrogator that supports the use of II/SI code operation~~, if~~ and is operating with an SI code, must be configurable by the user to either:

a) not lockout non-SI capable transponders on the "matching" II code; or
b) use intermittent lockout for this "matching" II code.

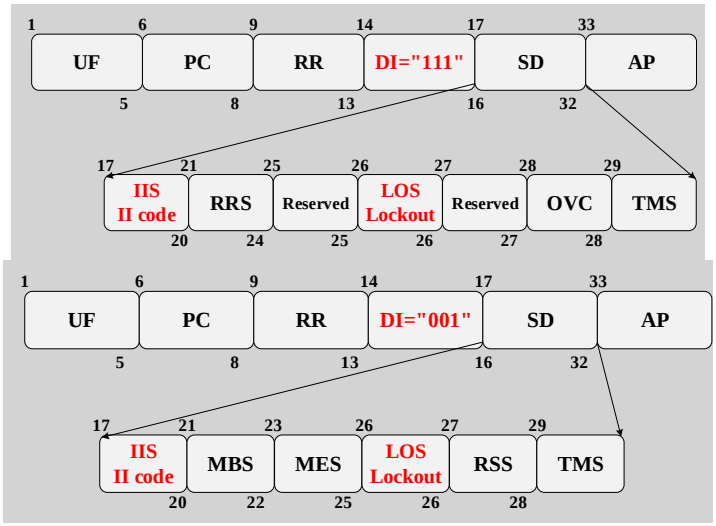
Note.— This is to allow ~~neighbouring~~ interrogators (supporting the use of II/SI code operation) with overlapping coverage and operating with the “matching” II code or with an SI code matching the same II code to acquire the Mode S II-only (non-SI capable) transponders on the “matching” II code. No lockout, or intermittent lockout, on the matching II code enables interrogators using the matching II and the interrogators using the matching SI codes to acquire the Mode S II-only aircraft transponder using the transponder replies on the matching II code. If there is no overlapping with an adjacent ground station using a matching II or a matching SI code, lockout may continue to be used.

1.2.9.1 A Mode S II/SI capable interrogator operating on SI code will use a selective interrogation (Roll-Call) to provide surveillance and to lockout (or intermittent lockout) the mode S II/SI capable transponder by setting the DI field to “011”, and filling the interrogator’s SI code into the SIS subfield, setting the LSS subfield to “1”. As shown in the figure below. (Re. ICAO Annex 10 Vol.4, Ed. 2017, paragraph 3.1.2.6.1.4)

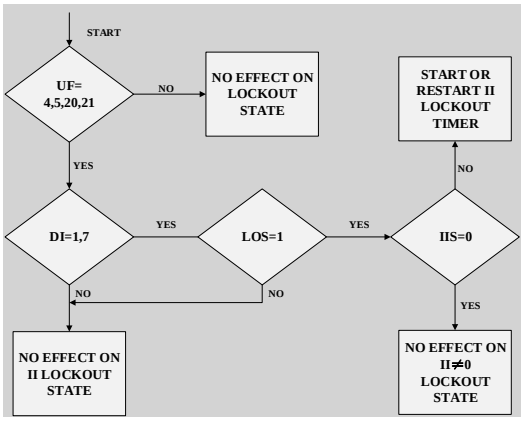


1.2.9.2 The Mode S II/SI interrogator that supports the use of II/SI code operation and that operates on SI code must either not lock-out the Mode S II-only transponder or use the “matching” II code to intermittently lock-out (intermittent lock-out) the Mode S II-only transponder. In that case, the Mode S interrogator can use the selective interrogation (Roll-

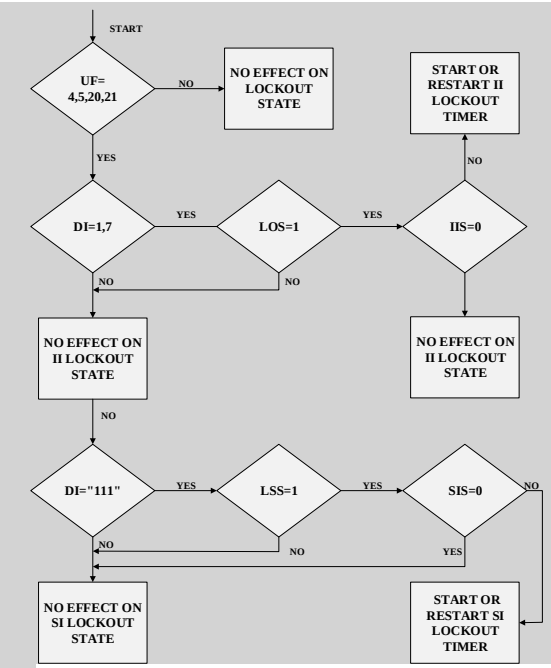
Call) to lockout the Mode S II only transponder by setting the DI field to “111” or “001, filling the interrogator’s “matching” II code into the IIS subfield and setting the LOS subfield to “1 “.



1.2.9.3 Once a confirmed selective interrogation (Roll-Call) is accepted, the Mode S II-only transponder will use the following logic to determine the lockout activity.



1.2.9.4 Once a confirmed selective interrogation is accepted, the Mode S II/SI capable transponder will use the following logic to determine the lockout activity.



Note (1): According to Annex 10 Volume IV SIS=0 is not used.

1.2.10 The interrogator that supports the use of II/SI code operation~~, if~~ and is operating with an II code, must be configurable by the user to either:

a) not lockout Mode S transponders that do not report the SI capability in Register 10_{16} or cannot report their data link capability (Register 10_{16}); or
b) use intermittent lockout for Mode S transponders that do not report the SI capability in Register 10_{16} or cannot report their data link capability (Register 10_{16}).

Note.— This is to allow ~~neighbouring~~ interrogators (supporting the use of II/SI code operation) with overlapping coverage and operating with an SI code ~~and the~~ "matching" the II code to acquire the Mode S II-only (non-SI capable) transponders on the "matching" II code.

1.2.10.1 The Mode S II/SI capable interrogator (supporting the use of II/SI code operation) that operates with an II code can distinguish between a Mode S II-only transponder and a Mode S II/SI capable transponder using the content of the reported register 10_{16} (Incorrect BDS1,0 information should be taken into consideration). But some Mode S transponders may report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are in practice not SI capable.

1.2.10.2 Using this mechanism, the Mode S II/SI capable transponders will be locked out, whereas the Mode S II-only (non-SI capable) transponders will not be locked out on the II code. Therefore, the Mode S II-only transponder can be acquired on the "matching" II code by an overlapping Mode S II/SI interrogator (supporting the use of II/SI code operation) operating on an SI code "matching" the II code. A Mode S II/SI capable transponder that is locked out on II code by a Mode S II/SI interrogator is not locked out on any "matching" SI code since this transponder can decode the field "CL" and reply with the SI code to the Mode S SI interrogator.

1.2.11 The table below provides the acquisition and lockout of Mode S II-only transponder and Mode S II/SI capable transponder by Mode S interrogator:

- Mode S II-only interrogator not supporting the II/SI code operation and operating on II code,
- Mode S II/SI capable interrogator not supporting the II/SI code operation and operating on II code or SI code,
- Mode S II/SI capable interrogator supporting the II/SI code operation and operating on II code or SI code.

	II/SI code operation	IC	Acquisition Mode S II-only transponder	Acquisition Mode S II/SI capable transponder	Lockout Mode S II-only transponder	Lockout Mode S II/SI capable transponder
Mode S II-only interrogator	NO	**II code**	**YES** on II code	**YES** on II code	**YES**[2]	**YES**

Mode S II/SI capable interrogator	NO	**II code**	**YES** on II code	**YES** on II code	**YES**[2]	**YES**
		SI code	**NO**[1]	**YES** on SI code	**Not acquired**[3]	**YES**
	YES	**II code**	**YES** on II code	**YES** on II code	**NO**[4]	**YES**
		SI code	**YES** on **matching II code**	**YES** on SI code	**NO**	**YES**

Figure H-4: Acquisition and Lockout of Mode S transponders by Mode S interrogators

Notes:

[1] The Mode S II/SI capable interrogator sends all-call interrogations on SI code. The Mode S II-only transponder decodes the matching II code in the all-call interrogations and replies on the matching II code. The Mode S II/SI capable interrogator, which does no support II/SI code operation, decodes an II code in the all-call replies and rejects the replies. The Mode S II-only transponder is not acquired by the interrogator.

[2] The Mode S II-only transponder is locked on the II code. Therefore, it cannot be acquired on the "matching" II code by Mode S II/SI capable interrogator supporting the II/SI code operation and operating on matching SI codes in the overlapping coverage.

[3] The Mode S II-only transponder cannot be acquired by the interrogator. Therefore, it cannot be selectively interrogated and cannot be locked out.

[4] The Mode S II/SI capable interrogator supporting II/SI code operation and operating on II code uses the Bit 35 of Register 10_{16} to determine if a Mode S aircraft transponder is SI capable. No lockout or intermittent lockout is applied to Mode S transponders that do not report the SI capability in Register 10_{16} or cannot report their data link capability (Register 10_{16}).

1.2.~~11~~12 This technique may be used in an environment where there is a need for a region to introduce the use of SI codes by Mode S ground stations and at the same time ~~must only be used to~~ detect aircraft not equipped with SI code capable transponders~~entering mandated SI code airspace so that appropriate action can be taken (e.g. they can be re-routed out of such airspace)~~.

…

1.3.4 The PI field of an all-call reply, downlink format (DF) = 11, elicited by a Mode S-only all-call interrogation (UF = 11) is encoded using the IC received in the interrogation that elicited the reply. This is composed of CL and IC fields of the all-call interrogation. This address is used in the encoding of the PI field in exactly the same manner as the transponder Mode S address is used to generate the address parity (AP) field. Ground stations operating in the multisite mode decode all-call replies using their own IC as the expected address. All-call FRUIT replies produced by adjacent ground stations will not be accepted by the local ground station since they would be encoded using a different IC. This rejection of all-call replies by the IC eliminates the possibility of extraneous all-call tracks being formed from Mode S FRUIT replies. In case the II/SI code operation is used the all-call replies received on the matching II code are not considered as FRUIT.

…

1.3.7 Implementation of SI code capability (Annex 10, Volume IV, Chapter 2, 2.1.5.1.7.1) can be determined by monitoring bit 35 of the data link capability report (register 10_{16}). This report should be routinely extracted at track acquisition. ~~SI codes cannot be used in a region of airspace until all of the Mode S aircraft are equipped for SI codes.~~ This monitoring should continue after SI codes are put into use to identify any transponder that is not SI-capable. Follow-up action should be initiated for aircraft that are detected that are not equipped with SI codes.

~~1.3.8 The reason that all aircraft must be SI-equipped is that a non-SI code-capable Mode S transponder will misinterpret the SI code contained in the Mode S-only all-call interrogation. The II or SI code included in a Mode S-only all-call interrogation is contained in a 7-bit field composed of the 3-bit CL field and the 4-bit IC field as follows:~~
~~CL coding (in binary):~~

~~000 signifies that IC field contains the II code~~
~~001 signifies that IC field contains SI codes 1 to 15~~
~~010 signifies that IC field contains SI codes 16 to 31~~
~~011 signifies that IC field contains SI codes 32 to 47~~

~~100 signifies that IC field contains SI codes 48 to 63~~

~~1.3.9 A transponder that does not support SI codes will not detect the CL field and will therefore interpret the IC field as always containing an II code. This causes the mapping of a set of SI codes into an II code. For example, ICs of II = 1 and SI = 1, 17, 33 and 49 will all have "0001" in the IC field. If an aircraft not equipped for SI codes is operating in a region of overlapping coverage of interrogators with II = 1 and SI = 17, the following interaction will occur:~~

~~a) if the aircraft is acquired first by the II = 1 interrogator, the aircraft will be locked out to II = 1. An all-call interrogation from the SI interrogator expressing SI = 17 will not elicit an all-call reply because the transponder interprets the code as II = 1, and it is locked out to II = 1; and~~

~~b) if the aircraft is acquired first by the SI interrogator, the transponder will reply to the SI = 17 all-call interrogation since it is not locked out to II = 1. The SI interrogator will not be able to lock out the transponder, since the mechanism for II and SI code lockout is entirely different. Therefore, the transponder will not recognize the SI lockout command (and will not change its lockout status to any II code).~~

~~1.3.10 Thus, with a transponder not equipped with SI code capability, there will never be a loss of surveillance coverage for an interrogator with an II code. Surveillance loss can only happen to the SI code interrogator and then only for a certain combination of II and SI codes.~~

1.3.~~11~~8 The transition to SI codes is manageable through monitoring compliance to the SI code requirement via the data link capability report and (where possible for fixed interrogators) assigning II and SI codes for adjacent interrogators to avoid possible interaction. It is possible to assign more than one SI code to an interrogator on a sector basis. This approach might be useful as another means to avoid interacting SI and II codes. For mobile interrogators, or for fixed interrogators where non-interacting SI and II codes cannot be used, a low rate of lockout override Mode S-only all-call interrogations by the SI code interrogator can be used to acquire the occasional non-SI code Mode S transponder. Another means for managing this situation is for the interrogators operating with II codes to periodically remove lockout for non-SI equipped Mode S transponders to ensure acquisition by SI interrogators.

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APPENDIX J

MODE S IMPLEMENTATION

…

7.4 Mode S radars can be configured to provide different types of radar coverage as already reported in section 3.5 of this Appendix:

a) Designated Operational Coverage (DOC): The volume of airspace, within which a Mode S facility is needed operationally and the use of specified interrogator codes is protected.

Note 1.— The volume of airspace can be defined either by using a unique range and height for the whole coverage, or by using a range and height per sector, or by using coverage maps in a common grid defined in a global WGS-84 system of coordinates (See 3.5.2 and 3.5.3 in this Appendix).
Note 2.— In this manual, the Designated Operation Coverage is also referred to as Surveillance Coverage
Note 3.— In the DOC, selective interrogations are performed;

~~a) surveillance coverage in which selective interrogations can be performed;~~

b) lockout coverage where the aircraft will be locked out once acquired (i.e. where the aircraft does not reply anymore to the all-call interrogations made using the specified interrogator code); and

c) data link coverage where Mode S data-link exchanges including the extraction of airborne data may be ~~extracted~~ confined.

7.4.1 All aforementioned ~~"~~coverages~~"~~ ~~should~~ may be configured differently depending on manufacturers and local/regional agreements. The correct configuration of the designated operation coverage ~~lockout coverage~~ is critical as it directly impacts on the interoperability with the adjacent radars using the same interrogator code. ~~The different coverage can be configured by a maximum range per sector or by using coverage maps defined in a global system of coordinates like the - WGS-84 system of coordinates~~.

7.4.2 Radar designated operational coverage, especially the radar lockout coverage, shall be carefully configured to ensure interoperability with the adjacent radars using the same or matching interrogator code. This may force the

implementing authority to think about the real operational requirement rather than just use the maximum available ~~physical coverage~~ range limited only by the radio horizon and named radio range in this document. In general, high diligence is needed during planning and implementation of new Mode S radars to avoid compromising the performance of existing ones that operate in the same geographic area.

7.4.3 The correct configuration of the lockout coverage is critical as it directly impacts on the interoperability with the adjacent radars using the same interrogator code. The volume of airspace where lockout is performed can be either identical to the DOC or can be specified in a sub-volume of the DOC defined as lockout coverage that can be programmed separately.

7.4.4 Mode S radar must be configured to ensure that Mode S air-ground datalink protocols can be used safely. The volume of airspace where air-ground datalink is performed can be either identical to the DOC or can be specified in a sub-volume of the DOC defined as data link coverage that can be programmed separately.

…

~~7.27 ICs are a scarce resource. Before implementing Mode S radars, it is necessary to coordinate the allocation of the required ICs with all the other civil and military users operating Mode S radars in the same area. In general, this requires the establishment of a regional coordination process to allocate the ICs. The coordination between the civil aviation authorities is managed by the regional offices of ICAO, which may delegate that task to some other organizations (e.g. FAA and EUROCONTROL). If military authorities use Mode S in the same area, they must also be involved in the IC coordination process. Regional agreements should ideally be in place to facilitate the allocation of ICs. In areas where only a few Mode S radars are deployed, a simple paper process can be sufficient to ensure that there is no overlap between two radars using the same code. However, where a large number of Mode S radars with overlapping coverage have been implemented (e.g. Europe and North America), a computerized tool for managing ICs would be helpful.~~

…

8. PLANNING CRITERIA FOR THE COORDINATION OF SSR MODE S INTERROGATOR IDENTIFIER (II) AND SURVEILLANCE IDENTIFIER (SI) CODES

8.1 Introduction

8.1.1 Applicability of planning criteria

8.1.1.1 Mode S surveillance operation requires that both the SSR Mode S ground station and the SSR Mode S equipped aircraft are capable of identifying each other. The aircraft is identified in this process by ~~the~~ its 24-bit aircraft address~~; the~~ which is transmitted by the transponder. The SSR Mode S ground station (interrogator) is identified by its ~~interrogator code,~~Interrogator Code (IC), which can either be an II code (Interrogator Identifier) or ~~a~~ an SI code (Surveillance Identifier).

8.1.1.2 Four bits are available for 16 different II codes ~~are available~~ for Mode S II interrogators. II code 0 requires special handling and ~~is~~ does not ~~further addressed here (see Annex 10 Volume IV, Chapter 3, 3.1.2.5.2.1.2.3).~~participate in the Mode S interrogator code assignment activity in this chapter. This leaves II codes 1-15 for assignment to ~~fixed~~ Mode S II code ground stations ~~with overlapping coverage~~. In some regions, certain II codes have been reserved for specific purposes and are not available for general assignment. For aircraft complying with the provisions of Annex 10, Volume IV, Amendment 73 (or later), an additional 63 codes known as SI codes can be used~~, which adds significant complexity when assigning and operating SI codes~~. Full use of these codes requires that all Mode S transponders in these regions are equipped with the provisions from Annex 10 (Mode S II/SI capable transponders). In regions where Mode S interrogators are planned to operate with SI codes, and where not all Mode S transponders comply with these provisions, special measure can be taken to allow, during the transition phase, for the continued operation of Mode S transponders that do not comply with the provisions from Annex 10 as per Amendment 73 or later (Mode S II-only transponders). This adds significant complexity when assigning and operating SI codes and also reduces significantly the efficiency in Mode S assignment planning during the transition phase.

8.1.1.3 This complexity results from the fact that SI codes are a later addition to the ICAO SARPs for SSR Mode S transponders (1998) and the use of SI codes is basically not compatible with Mode S II transponders that do not comply with these SARPs. ~~Currently, many~~ Mode S interrogators and transponders that are in operation ~~do~~ may not have SI code capability. Therefore, it cannot be assumed that all transponders in any region of airspace are 100 per cent equipped to handle both SI and II codes, even ~~if~~ in areas where a mandate exists.

8.1.1.4 Aircraft without SI code capability operating in designated ~~II and/or~~ SI code airspace require special handling to ensure that they can be placed in surveillance by all covering Mode S interrogators ~~The level of complexity necessary to provide reliable service to aircraft which are not equipped with SI code capability is beyond the scope of the planning criteria in this appendix. Therefore, this technique of SI code assignment is not further addressed here, and these~~

~~planning criteria described below can only be used for assignment of II codes~~ that are operating with Mode S SI codes. This can be achieved by configuring the Mode S SI interrogator to accept the all-call reply from a Mode S II-only transponder on the "matching" II code as is clarified in Appendix H.

~~*Note. — For more information on the assignment and management of SI codes, see ICAO EUR Doc 024 – IC Allocation for the European Region and Eurocontrol IC Planning Tool.*~~

~~8.1.2 Selective interrogation of Mode S aircraft~~

8.1.1.5 Interrogator Codes are a scarce resource. Before implementing Mode S interrogators, it is necessary to coordinate the assignment of the required interrogator codes with *all* users operating Mode S in the same Region or area. This requires the establishment of a regional coordination process to assign Interrogator Codes. The Regional coordination of interrogator code assignments is managed by the Regional Offices of ICAO. Regional agreements need to be in place to facilitate the coordination of the assignment of interrogator codes. The coordination of Mode S interrogator code assignments between regions in case where the coverage of an interrogator overlaps into an adjacent region is also performed by the ICAO ~~the~~ Regional Offices.

8.1.2 Acquisition, selective interrogations and lockout of Mode S aircraft

8.1.2.1 In order to selectively interrogate a Mode S-equipped aircraft, the interrogator (SSR Mode S ground station) needs to know the aircraft's ~~Mode S~~24-bit aircraft address and its approximate position. To acquire the address and position of a Mode S-equipped aircraft, the interrogator transmits all-call interrogations. A Mode S equipped aircraft will respond to such interrogations with its unique 24-bit aircraft address. When the aircraft is outside the DOC of the interrogator, these replies are discarded by the interrogator. When the aircraft is inside the DOC of the interrogator (Point A and point P in Figure J-15 and Figure J-16) the all-call replies from the aircraft are accepted by the interrogator. After two or three scans (Re. Appendix H, paragraph 1.1.1), the aircraft is acquired by the interrogator (Point B and point Q in Figure J-15 and Figure J-16) and can be selectively interrogated. The Mode S-equipped aircraft should be locked out from replying (instructed not to respond) to subsequent Mode S all-call interrogations using the same II or SI code in order to minimize all call synchronous garbling. This lockout condition is controlled by the Mode S interrogator through Mode S selectively addressed interrogations, or Roll-Calls. If the lockout coverage of the interrogator is equivalent to its DOC, then the Mode S-equipped aircraft should be locked out (Point C and Point R in Figure J-15) once it is selectively interrogated by the interrogator anywhere in the DOC. If the lockout coverage is defined separately in a sub-volume of the DOC, then the Mode S-equipped aircraft should be locked out by the interrogator only when it is in the lockout coverage (Point C and Point R in Figure J-16).
Acquisition can also be accomplished by provision of the address and position through other means (e.g., clustering of interrogators, which is described in 8.3.3 of this appendix).

8.1.2.1.1 The various steps necessary to acquire, to selectively interrogate and to lock out an aircraft Mode S transponder are displayed in Figure J-15 and Figure J-16 below. These 2 figures correspond to the two methods that can be used to define the DOC that is programmed in Mode S ground stations. In Method A the lockout coverage is identical to the DOC. In Method B the lockout coverage is applied in a volume of airspace smaller than the DOC. These 2 methods are further described in paragraph 8.4.2.

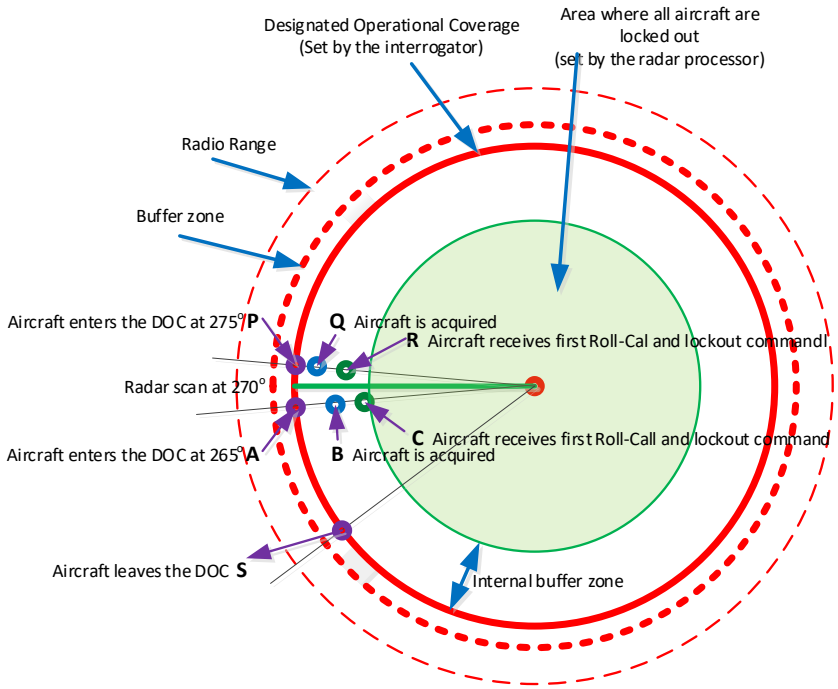


Figure J-15 – Acquisition, selective interrogations and lockout for an SSR Mode S transponder with lockout coverage set to DOC (Method A - External Buffer zone)

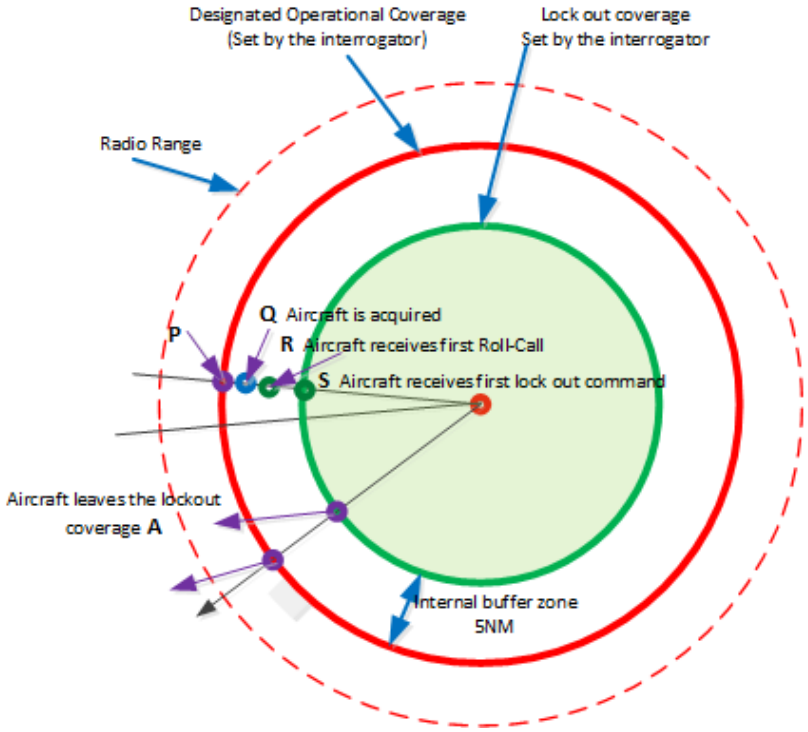


Figure J-16 – Acquisition, selective interrogations and lockout for an SSR Mode S transponder in lockout coverage as sub-volume of DOC (Method B - Internal Buffer Zone)

8.1.2.2 ~~The~~One of the conditions for a valid reply is that the aircraft is within the designated operational range coverage of the SSR Mode S interrogator (Point A and point P in Figure J-15 and Figure J-16). This is the ~~range~~

coverage within which the interrogator accepts all-call replies from the aircraft ~~or generates selective interrogations to~~. After two or three scans, when the interrogator has established a track for the aircraft using its all-call replies, the aircraft can be acquired by the interrogator. The interrogator will then send selective interrogations (Roll Calls) to the aircraft. If the lockout coverage of the interrogator is equivalent to its DOC, then the selective interrogations will contain a lockout command. If the lockout coverage is defined separately as a sub-volume of the DOC, then the selective interrogations will contain a lockout command only when the aircraft is inside the lockout coverage. The lockout command prevents the aircraft to respond to all-call interrogations on the IC used by the interrogator. During the time that the aircraft is inside the DOC of the interrogator, until it has been acquired and selectively interrogated (Roll Calls), the position of the aircraft is not presented to the display of the air traffic controller. Depending on the position of the aircraft relative to the position of the scanning beam of the interrogator, the course of the aircraft and the speed of the aircraft, the (worst case) distance can be between 3 NM (Point R in Figure J-15) to about 4 NM (Point C in Figure J-15). This generates inside the DOC of the interrogator a volume of airspace within which all aircraft are acquired and are selectively interrogated (Roll Calls). This volume is about 4 NM less than the DOC. ~~aircraft.~~ When the aircraft is outside the designated operational ~~range~~ coverage of the SSR Mode S interrogator, while the aircraft may receive (and respond to) all-calls from this interrogator the interrogator does not accept all-call replies received from the aircraft transponder to all-call interrogations. In addition, the ~~The~~ interrogator will ~~also~~ no longer ~~generate~~ request lock-out in selective interrogations to the "acquired" aircraft that have left the ~~designated operational range~~ the lockout coverage if defined separately in a sub-volume of the DOC, in which case, after 18 seconds, the aircraft will no longer be locked out for all-call interrogations from this interrogator. The interrogator will also no longer generate selective interrogations to the "acquired" aircraft that have left the designated operational coverage. ~~In both cases~~, ~~the aircraft may receive (and respond to) all-calls from this interrogator, but the responses will not be accepted by this interrogator (SSR Mode S ground station).~~

8.1.2.3 Once the ~~response~~ reply from the aircraft is received by the interrogator and the aircraft is within the designated operational ~~range~~ coverage of the interrogator, the aircraft will be added to the interrogator's list of acquired aircraft — the aircraft is in an "acquired" state. The designated operational ~~range~~ coverage is programmed into the SSR Mode S interrogator and is promulgated by the State responsible for the SSR Mode S ground station.

8.1.2.4 Once the aircraft is in the acquired state (i.e. it has been added to the interrogator's list of aircraft, of which the 24-bit aircraft address has been acquired), the aircraft is instructed to no longer respond to (or be "locked-out" from) Mode S all-calls on the interrogator code used by ~~from~~ that particular ground station, in order to minimize all-call synchronous garbling. This is achieved when the aircraft receives Mode S selectively addressed interrogations (Roll Calls) that contain an instruction to the on-board SSR Mode S transponder not to respond to Mode S all-call interrogations on the II or SI code used by ~~from~~ that interrogator.

~~8.1.2.5 When an aircraft is within the designated operational range of two (or more) Mode S ground stations, it must be acquired and locked out (from all-call interrogations) by each Mode S ground station. This is known as multisite acquisition and multisite lockout. Measures need to be taken to avoid aircraft, within the designated operational range of more than one SSR Mode S interrogator (the SSR Mode S ground stations have overlapping coverage), receiving interrogations from interrogators with the same interrogator identifier. This is achieved by ensuring that Mode S interrogators with the overlapping designated operational range have been assigned different interrogator identifiers or are coordinated for ground communications (see 8.3.3 of this. appendix). The assignment of interrogator identifier codes is subject to regional coordination.~~

8.1.2.5 When an aircraft is within the designated operational coverage of two (or more) Mode S ground stations, it must be acquired and locked out (from responding to all-call interrogations) by each Mode S ground station. This is known as multisite acquisition and multisite lockout.

There are different options to ensure that the aircraft is acquired by different interrogators with overlapping coverage:

- Mode S interrogators with overlapping coverage are assigned different IC (II or SI code) considering possible interference between II code and SI code (as described in section 8.2.6 below), as defined in paragraph 8.3.2 of this Appendix.
- Mode S interrogators are coordinated using ground communications (clustering of interrogators) as defined in section 8.3.3 of this Appendix.
- Using multiple interrogator codes by a single Mode S ground station, as defined in section 8.3.4.1 of this Appendix.
- The DOC of Mode S interrogators operating on the same IC is reduced to no overlap as defined in section 8.3.4.2 of this Appendix.
- Lockout override is applied by Mode S interrogators in the sector covering the volume of airspace where DOCs

overlap to ensure the aircraft can be acquired in the volume where DOCs overlap as defined in section 8.3.4.3 of this Appendix.

- Lockout is not applied in the overlapping DOCs, meaning that only the lockout coverages have to be reduced to avoid overlapping, as defined in section 8.4.4.3 of this Appendix. This Options only applies to Method B.

The capability to program different coverages for DOC and lockout provides a way to support an optimization of IC assignment, for example applying surveillance but not lockout in overlapping coverage.

The assignment of II and SI codes is subject to regional coordination.

8.2 Interrogator Identifier and Surveillance Identifier

8.2.1 Mode S II-only capable interrogators and transponders[7] (See also Figure J-17 and J-18)

8.2.1.1 The interrogator identifier (II) is a four-digit code (0 – 15) which is transmitted by the SSR Mode S ground station when transmitting a Mode S-only all-call (or a Mode S II selective) interrogation. ~~It~~The II code serves the purpose of identifying the SSR Mode S ground station. When the aircraft is operating in an area where two (or more) SSR Mode S ground stations have overlapping coverage, different II codes or reduced coverages (as described in section 8.1.2.5) are required to ensure that all SSR Mode S ground stations can provide surveillance ~~on~~ to the aircraft independent from each other. In special cases, overlapping SSR Mode S ground stations may share the same II code (see 8.3.3 of this ~~appendix~~ Appendix).

~~8.2.2 A Mode S-only all-call interrogation elicits replies only from Mode S transponders. The (uplink) format of the Mode S-only all-call is shown in Figure J-15. (See Annex 10, Volume IV, Chapter 3, 3.1.2.5.2.1):~~

~~1 6 10 14 17 33 bit no.~~

~~01011~~	~~PR~~	~~IC~~	~~CL~~	~~spare~~	~~AP~~

~~total 56 bits~~

~~5 9 13 16 32 56 bit no.~~

~~Figure J-15. Uplink format 11~~

~~8.2.2.1 This message contains the following information:~~

~~Bit 1-5 01011 (uplink format; decimal value 11):~~
~~If the uplink format is 01011 (decimal value 11), the content of bits 6 – 56 is as described below:~~

~~Bit 6-9 PR (probability of reply); this information is not further addressed here.~~

~~Bit 10-13 IC (interrogator code):~~
~~These four bits contain the interrogator identifier (0-15) or the last four bits of the surveillance identifier (SI).~~
~~Bit 14-16 CL (code label):~~

~~If CL = 000, the information in the IC field is the interrogator identifier.~~

~~If CL = 001 to 100 (decimal value 1 to 4), the information in the IC field contains the last four bits of the surveillance identifier.~~

~~Bit 33-56 AP (address/parity):~~
~~For a Mode S-only all-call, the address consists of 24 one's, on which the parity is overlaid.~~

~~8.2.3 A Mode S-only all-call reply from the aircraft, in which the II (or SI) is encoded in the PI field, has the format shown in Figure J-16. (See Annex 10, Volume IV, Chapter 3, 3.1.2.5.2.2):~~

~~1 6 9 33 bit no.~~

~~01011~~	~~CA~~	~~AA~~	~~PI~~

~~total 56 bits~~

5 8 32 56 bit no.

Figure J-16. Downlink format 11

8.2.3.1 This message contains the following information:

Bit 1-5 01011 (downlink format; decimal value 11)
If the downlink format is 01011 (decimal value 11), the content of bits 6 – 56 is as described below:

Bit 6-8 CA (capability)
An encoded definition of the communications capability of the transponder.

Bit 9-32 AA (address announced)
24-bit aircraft address.

Bit 33-56 PI (parity/interrogator identifier):

Interrogator identifier code (II or SI), on which the parity is overlaid.

Note. — The interrogator identifier is the same as that received by the aircraft in the all-call message as described in 8.2.1 of this appendix.

8.2.4 Following the Mode S-only all-call reply, the ground station will send a selective interrogation, which uses the format shown in Figure J-17 or Figure J-18. (See Annex 10, Volume IV, Chapter 3, 3.1.2.6.1 to 3.1.2.6.4):

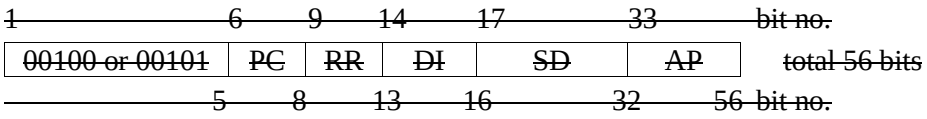


Figure J-17. Uplink formats 4 and 5

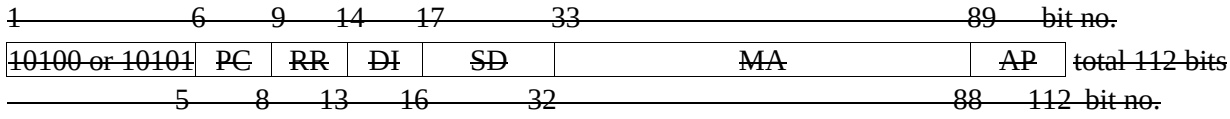


Figure J-18. Uplink format 20 and 21

8.2.4.1 This message contains the following information:

Bit 1-5 00100, 00101, 10100 or 10101 (Uplink Format; decimal value 4, 5, 20 or 21)

If the uplink format of the selective interrogation is 00100 (decimal value 4), the selective interrogation is a surveillance interrogation altitude request.

If the uplink format of the selective interrogation is 00101 (decimal value 5), the selective interrogation is a surveillance interrogation identity request.

If the uplink format of the selective interrogation is 10101 (decimal value 20), the selective interrogation is a Comm-A interrogation altitude request.

If the uplink format of the selective interrogation is 10101 (decimal value 21), the selective interrogation is a Comm-A interrogation identity (Mode A) request.

After obtaining the range, the azimuth and the 24-bit Mode S address from the all-call reply, a Mode S interrogator will start selective Mode S surveillance (of the aircraft) using the uplink format 4 (UF=4) interrogation to obtain a surveillance update of the altitude of the aircraft at every scan. At track initiation, the interrogator will also send an interrogation with the uplink format 5 (UF=5) to obtain the aircraft Mode A code. The interrogator does not need to continuously read out the Mode A code since changes in the Mode A code are indicated in the flight status field of a Mode S reply with the downlink format DF = 4, 5, 20 or 21.

~~Bit 6-8 PC (protocol)~~

~~If PC=1, the transponder shall lock out to II=0 (non-selective lockout).~~

~~Bit 9-13 RR (reply request); command the length and content of a requested reply.~~

~~Bit 14-16 DI (designator identification).~~

~~The designator identification identifies the structure of the SD field. (See Annex 10, Volume IV, Chapter 3, 3.1.2.6.1.3 for details)~~

~~Bit 17-32 SD (Special Designator)~~

~~Contains a number of control codes, specific to SSR, including the interrogator identifier code of the interrogator and the lockout subfield (LOS) bit that commands multisite lockout (See Annex 10, Volume IV, Chapter 3, 3.1.2.6.1.4 for details).~~

~~Bit 33-56 AP (address/parity) *Uplink Formats 4 and 5 only:*~~

~~24-bit aircraft address of the aircraft which is selectively interrogated and on which the parity is overlaid.~~
~~Bit 33-88 MA (message; Comm. A) *Uplink format 20 and 21 only:*~~

~~The MA field contains a data link message to the aircraft.~~

~~Bit 88-112 AP (address/parity) *Uplink format 20 and 21 only:*~~

~~24-bit aircraft address of the aircraft which is selectively interrogated and on which the parity is overlaid.~~

~~8.2.5. The aircraft responds as requested by the selective interrogation. The process of selective interrogation and replies continues until the aircraft is outside the designated operational range of the SSR interrogator. As long as the aircraft receives the selective interrogations with LOS=1, it is locked out to all-calls from that interrogator.~~

8.2.2 Mode S II/SI capable interrogators and transponders[8] (See also Figure J-17 and J-18)

8.2.2.1 The surveillance Identifier (SI) is a four-bit code in the IC field of the All-Call message from a Mode S II/SI capable interrogator in conjunction with the three-bit code in the CL field that is set from binary code 001 – 100. This combination generates 63 SI codes as described in Appendix H, paragraph 1.2. Similar to the compatibility of Mode S II codes as described in 8.2.1.1, when the aircraft is operating in an area where two (or more) Mode S II/SI capable ground stations are operating with SI codes and overlapping coverage, different SI codes, reduced coverages or clustering of interrogators (as described in section 8.1.2.5) are required to ensure that all SSR Mode S SI interrogators can provide surveillance service to aircraft *which are equipped with Mode S II/SI capable* transponders.

Note.- This situation assumes that all aircraft are equipped with Mode S II/SI capable transponders.

8.2.3 Mixed environment with Mode S II-only and Mode S II/SI capable interrogators and transponders.

8.2.3.1 Of special concern is the case in a region where a transition of Mode S II-only equipment to Mode S II/SI equipment is taking place and both Mode S II-only and Mode S II/SI capable interrogators and transponders are in use.

8.2.3.2 Using the II/SI code operation technique as is described in Appendix H Paragraphs 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10 and 1.2.11, the Mode S SI interrogator that supports the use of II/SI code operation can be configured to accept the reply from the Mode S II-only capable transponder on the “matching” II code (the Mode S II-only capable transponder is not able to decode the content of the CL field in the all-call interrogations) using only the four-bit code in the IC field. In this case, the Mode S SI interrogator will either not lockout the Mode S II-only transponder or use intermittent lockout on the “matching” II code, to enable its acquisition by other Mode S interrogators (supporting the use of II/SI code operation) with overlapping coverage and operating with other SI or II codes with a matching code in the IC field. This mode of operation is configurable and is only required when there is an overlap with another ground station using a matching II or SI code.

[8] Mode S II/SI capable interrogators and transponders comply with the provisions of Annex 10, Volume IV, including Amendment 73

8.2.4 The format of the Mode S All-Call messages and the relevant reply from the transponder is in the figures below:

8.2.4.1 **All-Call interrogations.** – A Mode S-only all-call interrogation elicits replies only from Mode S transponders. The (uplink) format of the Mode S- II-only all-call and the Mode S II/SI all-call is shown in Figure J-17 and J-18

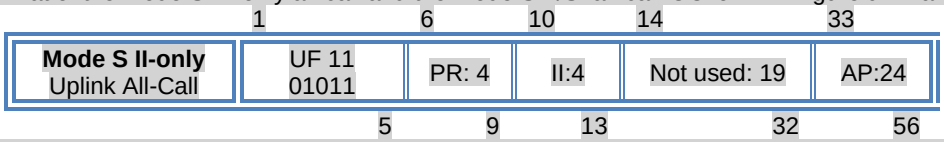


Figure J-17/1 Mode S All-Call structure for Mode S II-only all-call (Uplink format 11 old definition)

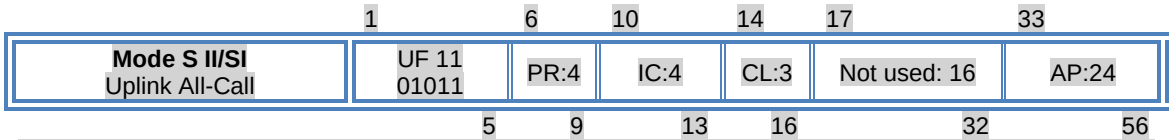


Figure J-17/2 Mode S All-Call structure for Mode S II/SI all-call (Uplink format 11 current definition)

8.2.5 All-Call replies. A Mode S-only all-call reply from the aircraft, in which the II (or SI) is encoded in the PI field, has the format shown in Figure J-18/1 and J-18/2

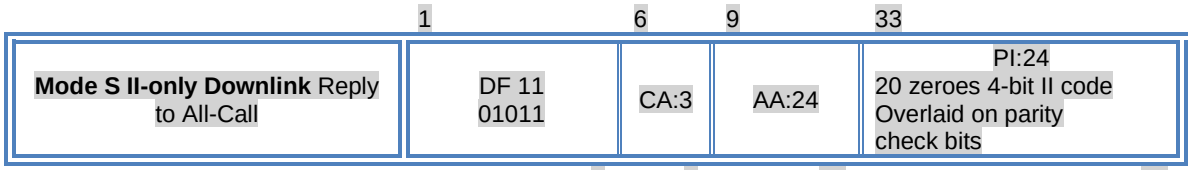


Figure J-18/1 All-Call reply from Mode S II-only transponder, downlink format 11

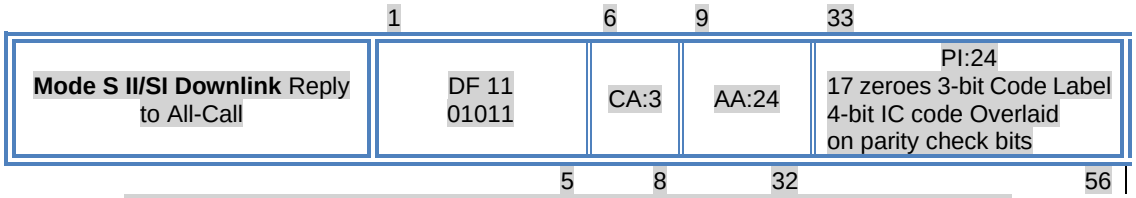


Figure J-18/2 All=Call reply from Mode S II/SI transponder, downlink format 11

8.2.5.1 In these messages:

UF: Uplink format. This uplink format field is the uplink format descriptor in Mode S interrogations and is encoded to 01011 (decimal 11) for all-call interrogations.

DF: Downlink format. This downlink format field is the downlink format descriptor in Mode S replies and is encoded to 01011 (decimal 11) for all-call replies.

AP: Address/parity. This 24-bit uplink field contains parity overlaid on the 24-bit aircraft address.

PI: Parity/interrogator identifier. This 24-bit downlink field contains the parity overlaid on the interrogator's identity code (IC). This field includes:

- For a Mode S II-only transponder:20 zeroes and the four-bit interrogator identifier
- For a Mode S II/SI capable interrogator 17 zeroes, the three-bit Code Label (CL) and the four-bit Interrogator Code (IC) from the All-Call message

8.2.6 Mode S II code or Mode S SI code assignment planning criteria.

8.2.6.1. A “matching” SI code is an SI code whose the binary format in the IC field is the same as the binary format in the IC field (or in the II field for Mode S II only interrogators that comply with the provisions of Annex 10, Volume IV, up to and including Amendment 71) of the II code. Each Mode S II code has four “matching” SI codes.

A “matching” II code is an II code whose the binary format in the IC field (or in the II field for Mode S II only interrogators that comply with the provisions of Annex 10, Volume IV, up to and including Amendment 71) is the same as the binary format in the IC field of the SI code. Each Mode S SI code has one “matching” II code.

More information is in Doc. 9924, Appendix H, paragraph 1.2.3

8.2.6.2. Mode S II-only interrogators

8.2.6.2.1 The interrogator must be assigned an II code as SI codes are not supported.

8.2.6.2.2 The table below provides guidance in the assignment of II codes and SI codes to Mode S radars (Mode S II-only interrogators and Mode S II/SI capable interrogators supporting or not the II/SI code operation) having a coverage overlapping the coverage of a Mode S II-only interrogator, depending on the capability of Mode S transponders (Mode S II-only transponders and Mode S II/SI capable transponders) flying in the airspace.

Considered interrogator (interrogator for which an Interrogator code is demanded): Mode S II-only interrogator Operating on II code Can operate with Mode S II-only and Mode S II/SI transponders				
Case	Capability of the overlapping interrogator:	Operating interrogator code	Condition	Transponder Type
A	Mode S II only	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
B	Mode S SI operating with II code (1)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
C	Mode S SI operating with SI code (1)	Any SI code, including a “matching” SI code	Overlap OK	II/SI
D	Mode S II/SI operating with II code (2)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
E	Mode S II/SI operating with SI code (2)	Non-matching SI code	Overlap OK	II-only and II/SI
		“Matching” SI code	No overlap	

Note.- Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note.2- Mode S II/SI means Mode S II/SI capable interrogator which does support the II/SI code operation

Case A, B and D: The DOC of the Mode S II-only interrogator cannot overlap with the DOC of any other Mode S interrogator operating on the same II code (and vice versa). This is because the Mode S II-only interrogator locks out Mode S transponders on its II code once they are acquired in its DOC. Once locked out, the Mode S transponders can therefore not be acquired by another Mode S interrogator operating with the same II code in the overlapping area.

Case C: The DOC of the Mode S II-only interrogator can overlap with the DOC of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator that does not support II/SI code operation and does operate on an SI code will not recognize the reply (on the "matching" II code) from a Mode S II-only transponder as a valid reply to its all-call interrogation on "matching" SI code.
*Note: Within the coverage of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that is operating with a Mode S SI code, the use of Mode S II-only transponders is prohibited.*

Case E: The DOC of the Mode S II-only interrogator cannot overlap with the DOC of a Mode S II/SI capable interrogator that supports II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator, that supports the II/SI code operation, can be configured to recognize the reply from the Mode S II-only transponder on the "matching" II code as a valid reply (not lockout or intermittently lockout is applied to the Mode S II-only transponder). However, this Mode S II-only transponder will be locked out by the Mode S II-only interrogator in the area of the overlap, preventing the acquisition by the Mode S II/SI capable interrogator that supports II/SI code operation.

Note.- where practicable, it is recommended to limit the II codes assigned to Mode S II-only interrogators to a small set of II codes in order to optimize the IC assignment.

8.2.6.3. Mode S II/SI capable interrogators that do not support the use of II/SI code operation and operating on II code.

8.2.6.3.1 The interrogator is assigned with an II code until all of the Mode S aircraft in the airspace are equipped with II/SI capable transponder because the interrogator is not able to acquire Mode S II-only transponders when operating on SI code.

8.2.6.3.2 The table below provides guidance in the assignment of II codes and SI codes to Mode S radars (Mode S II-only interrogators and Mode S II/SI capable interrogators supporting or not the II/SI code operation) having a coverage overlapping the coverage of a Mode S II/SI capable interrogator that does not support the use of II/SI code operation and that operates on II code, depending on the capability of Mode S transponders (Mode S II-only transponders and Mode S II/SI capable transponders) flying in the airspace.

Considered interrogator (interrogator for which an Interrogator code is demanded): Mode S II/SI capable interrogator that does not support the use of II/SI code operation; Operating on II code; Can operate with Mode S II-only and Mode S II/SI transponders				
Case	Capability of the overlapping interrogator:	Operating interrogator code	Condition	Transponder Type
A	Mode S II only	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
B	Mode S SI operating with II code (1)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
C	Mode S SI operating with SI code (1)	Any SI code, including a "matching" SI code	Overlap OK	II/SI
D	Mode S II/SI operating with II code (2)	Different II code	Overlap OK	II-only and II/SI
		Same II code	No overlap	
E	Mode S II/SI operating with SI code (2)	Non "matching" SI code	Overlap OK	II-only and II/SI
		"Matching" SI code	No overlap	

Note 1: Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation

Note 2: Mode S II/SI means Mode S II/SI capable interrogator which does support the II/SI code operation

Case A, B and D: The DOC of the considered Mode S interrogator cannot overlap with the DOC of any Mode S interrogator operating on the same II code (and vice versa). This is because the considered interrogator locks out

Mode S transponders on its II code once they are acquired in its DOC. Once locked out, the Mode S transponders can therefore not be acquired by another Mode S interrogator operating with the same II code in the overlapping area.

Case C: The DOC of the considered Mode S interrogator can overlap with the DOC of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator that does not support II/SI code operation, operating on an SI code, will not recognize the reply (on the "matching" II code) from a Mode S II-only transponder as a valid reply to its all-call interrogation on "matching" SI code.
*Note: Within the coverage of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that is operating with a Mode S SI code, the use of Mode S II-only transponders is prohibited.*

Case E: The DOC of the considered Mode S interrogator cannot overlap with the DOC of a Mode S II/SI capable interrogator that supports the II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator, that supports the II/SI code operation, can be configured to recognize the reply from the Mode S II-only transponder on the "matching" II code as a valid reply (not lockout or intermittently lockout is applied to the Mode S II-only transponder). However, this Mode S II-only transponder will be locked out by the considered Mode S interrogator in the area of the overlap, preventing the acquisition by the Mode S II/SI capable interrogator that supports II/SI code operation.

Note.- where practicable, it is recommended to limit the II codes assigned to Mode S II/SI capable interrogators that do not support the use of II/SI code operation to a small set of II codes in order to optimize the IC assignment.

8.2.6.4. Mode S II/SI capable interrogators that do not support the use of II/SI code operation and operating on SI code

8.2.6.4.1 The interrogator can be assigned an SI code only if all Mode S aircrafts in the airspace are equipped with II/SI capable transponder because the interrogator is not able to acquire Mode S II-only transponders when operating on SI code.

8.2.6.4.2 The table below provides guidance in the assignment of II codes and SI codes to Mode S radars (Mode S II-only interrogators and Mode S II/SI capable interrogators supporting or not the II/SI code operation) having a coverage overlapping the coverage of a Mode S II/SI capable interrogator that does not support the use of II/SI code operation and that operates on SI code, where only Mode S II/SI capable transponders are flying in the airspace.

Considered interrogator (interrogator for which an Interrogator code is demanded): Mode S II/SI capable interrogator that does not support the use of II/SI code operation Operating on SI code Can only operate with Mode S II/SI transponders				
Case	Capability of the overlapping interrogator:	Operating interrogator code	Condition	Transponder Type
A	Mode S II only	Any II code including the "matching" II Code	Overlap OK	II/SI
B	Mode S SI operating with II code (1)	Any II code including the "matching" II Code	Overlap OK	II/SI
C	Mode S SI operating with SI code (1)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	
D	Mode S II/SI operating with II code (2)	Any II code including the "matching" II Code	Overlap OK	II/SI
E	Mode S II/SI operating with SI code (2)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	

Note 1.- Mode S SI means *Mode S II/SI capable interrogator which does not support the II/SI code operation*

Note 2.- Mode S II/SI means Mode S II/SI capable interrogator which does support the II/SI code operation

When all Mode S aircrafts flying in the airspace are equipped with an II/SI capable transponder, there is no problem of interoperability between "matching" II code and "matching" SI code since all Mode S aircraft transponders interrogated with an SI code will reply on this SI code. Therefore, the only rule that applies to IC assignment is that two Mode S interrogators with overlapping coverage must not operate on the same IC.

Case A, B and D: The DOC of the considered Mode S interrogator can overlap with the DOC of a Mode S interrogator operating on the matching II code since considered Mode S interrogator operates on SI code in an airspace where all Mode S aircrafts are equipped with II/SI capable transponder. Therefore, it is not impacted by Mode S interrogator operating on other interrogator code.
Case C and E: The DOC of the considered Mode S interrogator cannot overlap with the DOC of any Mode S interrogator operating on the same SI code (and vice versa). The considered Mode S interrogator locks out Mode S transponders on its SI code once they are acquired in its DOC. Once locked out, the Mode S transponders cannot be acquired by another Mode S interrogator operating with the same SI code in the overlapping area.

8.2.6.5. Mode S II/SI capable interrogators supporting the use of II/SI code operation and operating on II code.

8.2.6.5.1 The interrogators need to be configured to **not** use lockout or use **intermittent lockout** for the Mode S II-only transponders, i.e. for transponders which report no SI capability in their datalink capability report (BDS 10) or cannot report their datalink capability (BDS 10).

8.2.6.5.2 When the interrogator is correctly configured, Mode S II-only transponders are not locked-out or are intermittently locked-out on the "matching" II code. Therefore, they can be acquired by Mode S II/SI capable interrogators supporting the use of II/SI code operation and operating on "matching" SI codes.

Note 1: information on the II/SI code operation techniques is provided in Appendix H, paragraph 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10 and 1.2.11.

Note 2: the interrogator relies on the content of Bit 35 of Register 10_{16} to determine if the aircraft is equipped with a Mode S II-only transponder. If incorrect capability is reported, i.e. Mode S II-only transponder reporting that it supports SI code in Bit 35, the Mode S II-only transponder will be locked on the II code and will not be acquired by Mode S interrogators operating on "matching" SI codes.

8.2.6.5.4 The table below provide guidance in the assignment of II codes and SI codes to Mode S radars (Mode S II-only interrogators and Mode S II/SI capable interrogators supporting or not the II/SI code operation) having a coverage overlapping the coverage of a Mode S II/SI capable interrogator that supports the use of II/SI code operation and that operates on II code, depending on the capability of Mode S transponders (Mode S II-only transponders and Mode S II/SI capable transponders) flying in the airspace.

<table>
<tr><td colspan="5">Considered interrogator (interrogator for which an Interrogator code is demanded):
Mode S II/SI capable interrogator that supports the use of II/SI code operation
Operating on II code
Can operate with Mode S II-only and Mode S II/SI transponders</td></tr>
<tr><td>Case</td><td>Capability of the overlapping interrogator:</td><td>Operating interrogator code</td><td>Condition</td><td>Transponder Type</td></tr>
<tr><td rowspan="2">A</td><td rowspan="2">Mode S II only</td><td>Different II code</td><td>Overlap OK</td><td rowspan="2">II-only and II/SI</td></tr>
<tr><td>Same II code</td><td>No overlap</td></tr>
<tr><td rowspan="2">B</td><td rowspan="2">Mode S SI operating with II code (1)</td><td>Different II code</td><td>Overlap OK</td><td rowspan="2">II-only and II/SI</td></tr>
<tr><td>Same II code</td><td>No overlap</td></tr>
<tr><td>C</td><td>Mode S SI operating with SI code (1)</td><td>Any SI code, including a "matching" SI code</td><td>Overlap OK</td><td>II/SI</td></tr>
<tr><td>D</td><td></td><td>Different II code</td><td>Overlap OK</td><td>II-only and II/SI</td></tr>
</table>

	Mode S II/SI operating with II code (2)	Same II code	No overlap	
E	Mode S II/SI operating with SI code (2)	Any SI code including a "matching" SI code	Overlap OK	II-only and II/SI

Note 1.- Mode S SI means *Mode S II/SI capable interrogator which does not support the II/SI code operation*

Note 2.- Mode S II/SI means Mode S II/SI capable interrogator which does support the II/SI code operation

Case A, B and D: The DOC of the considered Mode S interrogator cannot overlap with the DOC of any Mode S interrogator operating on the same II code (and vice versa). This is because the considered interrogator locks out Mode S transponders on its II code once they are acquired in its DOC. Once locked out, the Mode S transponders can therefore not be acquired by another Mode S interrogator operating with the same II code in the overlapping area.

Case C: The DOC of the considered Mode S interrogator can overlap with the DOC of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator that does not support II/SI code operation, operating on an SI code, will not recognize the reply (on the "matching" II code) from a Mode S II-only transponder as a valid reply to its all-call interrogation on "matching" SI code.
*Note: Within the coverage of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that is operating with a Mode S SI code, the use of Mode S II-only transponders is prohibited.*

Case E: The DOC of the considered Mode S interrogator can overlap with the DOC of a Mode S II/SI capable interrogator that supports the II/SI code operation and that operates with a "matching" SI code. The Mode S II/SI capable interrogator that supports the II/SI code operation and that operates on SI code can be configured to recognize the reply from the Mode S II-only transponder on the "matching" II code as a valid reply (not lockout or intermittently lockout is applied to the Mode S II-only transponder). This Mode S II-only transponder will **not** be locked out by the considered Mode S interrogator in the area of the overlap, enabling the acquisition by the Mode S II/SI capable interrogator that supports II/SI code operation and that operates on SI code.

8.2.6.6. Mode S II/SI capable interrogators supporting the use of II/SI code operation and operating on SI code.

8.2.6.6.1 Modes S II/SI capable interrogators supporting the use of II/SI code operation and operating with a Mode S SI code that are required to operate with Mode S II-only transponders need to be configured to:

- accept all call replies from Mode S II-only transponders on the "matching" II code, AND
- not lockout (or intermittent lockout) the Mode S II-only transponders

Note 1.- information on the II/SI code operation techniques is provided in Appendix H, paragraph 1.2.6, 1.2.7, 1.2.8, 1.2.9, 1.2.10 and 1.2.11.

Note 2.- when a Mode S II-only transponder receives an all-call interrogation from a Mode S interrogator operating on SI code, it will reply to the all-call interrogation on the "matching" II code. The interrogator relies on the interrogator code contained in the all-call replies to determine if an aircraft is equipped with a Mode S II-only transponder.

Note 3.- when starting operation on SI codes, it is not recommended to assign Mode S interrogator with the "matching" II code. It is recommended to remove all Mode S interrogators from an II code (and re-assign them on another II code) prior to assign the four "matching" SI codes to Mode S II/SI capable interrogators supporting the use of II/SI code operation.

8.2.6.6.2 The table below provide guidance in the assignment of II codes and SI codes to Mode S radars (Mode S II-only interrogators and Mode S II/SI capable interrogators supporting or not the II/SI code operation) having a coverage overlapping the coverage of a Mode S II/SI capable interrogator that supports the use of II/SI code operation and that operates on SI code, depending on the capability of Mode S transponders (Mode S II-only transponders and Mode S II/SI capable transponders) flying in the airspace.

Considered interrogator (interrogator for which an Interrogator code is demanded): Mode S II/SI capable interrogator that supports the use of II/SI code operation Operating on SI code Can operate with Mode S II-only and Mode S II/SI transponders				
Case	Capability of the overlapping interrogator:	Operating interrogator code	Condition	Transponder Type
A	Mode S II only	Non “matching” II code	Overlap OK	II-only and II/SI
		“Matching” II code	No overlap	
B	Mode S SI operating with II code (1)	Non “matching” II code	Overlap OK	II-only and II/SI
		“Matching” II code	No overlap	
C	Mode S SI operating with SI code (1)	Different SI code	Overlap OK	II/SI
		Same SI code	No overlap	
D	Mode S II/SI operating with II code (2)	Any II code including the “matching” II code	Overlap OK	II-only and II/SI
E	Mode S II/SI operating with SI code (2)	Different SI code	Overlap OK	II-only and II/SI
		Same SI code	No overlap	

Note 1.- Mode S SI means Mode S II/SI capable interrogator which does not support the II/SI code operation.

Note 2.- Mode S II/SI means Mode S II/SI capable interrogator which does support the II/SI code operation.

Case A and B: The DOC of the considered Mode S interrogator, operating on SI code, cannot overlap with the DOC of Mode S interrogator that does not support the use of II/SI code operation and that operates on the “matching” II code, because the Mode S interrogator that does not support the use of II/SI code operation locks out all Mode S transponders on its II code, including Mode S II-only transponders, once they are acquired in its DOC. Once locked out, the Mode S II-only transponders, which cannot be acquired on the SI code of the considered Mode S interrogator, cannot be acquired on the “matching” II code by the considered Mode S interrogator in the overlapping area.

Case C and E: The DOC of the considered Mode S interrogator cannot overlap with the DOC of any Mode S interrogator operating on the same SI code (and vice versa). The considered Mode S interrogator locks out Mode S transponders on its SI code once they are acquired in its DOC. Once locked out, the Mode S transponders cannot be acquired by another Mode S interrogator operating with the same SI code in the overlapping area.

*Note.- Within the coverage of a Mode S II/SI capable interrogator that does **not** support the II/SI code operation and that is operating with a Mode S SI code, the use of Mode S II-only transponders is prohibited.*

Case D: The DOC of the considered Mode S interrogator can overlap with the DOC of a Mode S II/SI capable interrogator that supports the II/SI code operation and that operates with a “matching” II code. The Mode S II-only transponder will **not** be locked out by the considered Mode S interrogator and by the Mode S II/SI capable interrogator that supports the II/SI code operation and that operates with a “matching” II code in the area of the overlap, enabling the acquisition by the other Mode S interrogator on the “matching” II code.

8.2.6.7. Capability reporting to ICAO

8.2.6.7.1 To support the Mode S II/SI code assignment planning, States need to provide ICAO with the following information:

a. Capability of Mode S interrogators:

- Mode S II-only interrogators;
- Mode S II/SI capable interrogators not configured to support II/SI code operation;

- Mode S II/SI capable interrogators configured to support II/SI code operation;

b. Capability of the Mode S transponders flying in the airspace:

- Mode S II-only and Mode S II/SI (mixed environment);
- Mode S II/SI (only using transponders that comply with Annes 10, Amendment 73 or later)

c. Coordinates of the Mode S interrogator

d. Designated Operational Coverage of the interrogator

e. Lockout coverage (if different from DOC)

8.2.6.8. Mode S II code congestion.

8.2.6.8.1 In areas where a large number of Mode S interrogators are Mode S II-only interrogators, a shortage of assignable II codes may become apparent. In this case, the best way to provide for (and make use of) the additional Mode S SI codes is to introduce Mode S II/SI capable interrogators supporting the II/SI code operation.

8.2.6.8.1.1 Such transition would require Mode S II-only interrogators to be modified into (or replaced with) Mode S II/SI capable interrogators supporting the II/SI code operation.

8.2.6.8.1.2 Other options are stochastic (sectorized) lockout override, sectorized intermittent lockout or no lockout of Mode S II-only transponders. With regard to the option of using stochastic lockout override, this will result in unnecessary increase of all-call replies since it also overrides the lockout of II/SI capable transponders. This option increases potential garbling. This method is not recommended and should only be used in extreme cases where no alternative Mode S II or SI code can be assigned. In order to minimize the RF pollution generated by stochastic lockout override while keeping a minimum of replies to allow acquisition of aircraft within a beam dwell, the Mode S-only all-call interrogation rate shall be limited. The rate can be limited according to the requirements mentioned in ICAO Annex 10 Volume IV (3.1.2.5.2.1.4.1).

8.2.6.8.2 In order to see such transition being implemented efficiently, such transition must take place prior to all Mode S II codes being used. Careful attention must be given to any overlap of the coverage with that of Mode S II-only interrogators.

Note : when starting operation on SI codes, it is recommended to remove all Mode S interrogators from an II code (and re-assign them on another II code) prior to assign the four "matching" SI codes to Mode S II/SI capable interrogators supporting the use of II/SI code operation.

8.2.6.8.3 Additional information on the transition to Mode S SI codes is also include in Doc. 9924, Appendix H, paragraph 1.3.11.

8.3 Coordination of Mode S ~~II codes~~ interrogator code of adjacent SSR Mode S interrogators ~~(ground stations)~~

Note: The examples below apply equally to the assignment of II codes or SI codes

8.3.1 Coordination of the SSR Mode S interrogator ~~identifier~~ codes is required when adjacent Mode S ground stations have overlapping designated operational coverage. ~~Coordination~~ Such coordination normally is required between adjacent States and ~~regions~~ adjacent Regions. To be acquired by a Mode S ground station, an aircraft must not be locked-out by another Mode S ground station operating on the same interrogator code. Therefore, an aircraft must not be locked-out on the interrogator code of a Mode S ground station when entering in its designated operational coverage (DOC). Considering that there is a timer of 18 seconds on the aircraft lockout state, a buffer zone where the aircraft does not receive lockout request is required to ensure the aircraft is no longer locked-out when entering in the DOC. There are two methods to define the DOC that is programmed in Mode S ground stations. These methods are further described in paragraph 8.4.2.

The examples described below illustrates the process of aircraft becoming (selectively) interrogated by SSR Mode S ground stations when travelling through the designated operational coverage ~~areas~~ of these facilities. In these

examples, one unique designated operational coverage is considered, with identical lockout coverage. ~~The example also clarifies the effect of the interrogator identifier codes in this process.~~

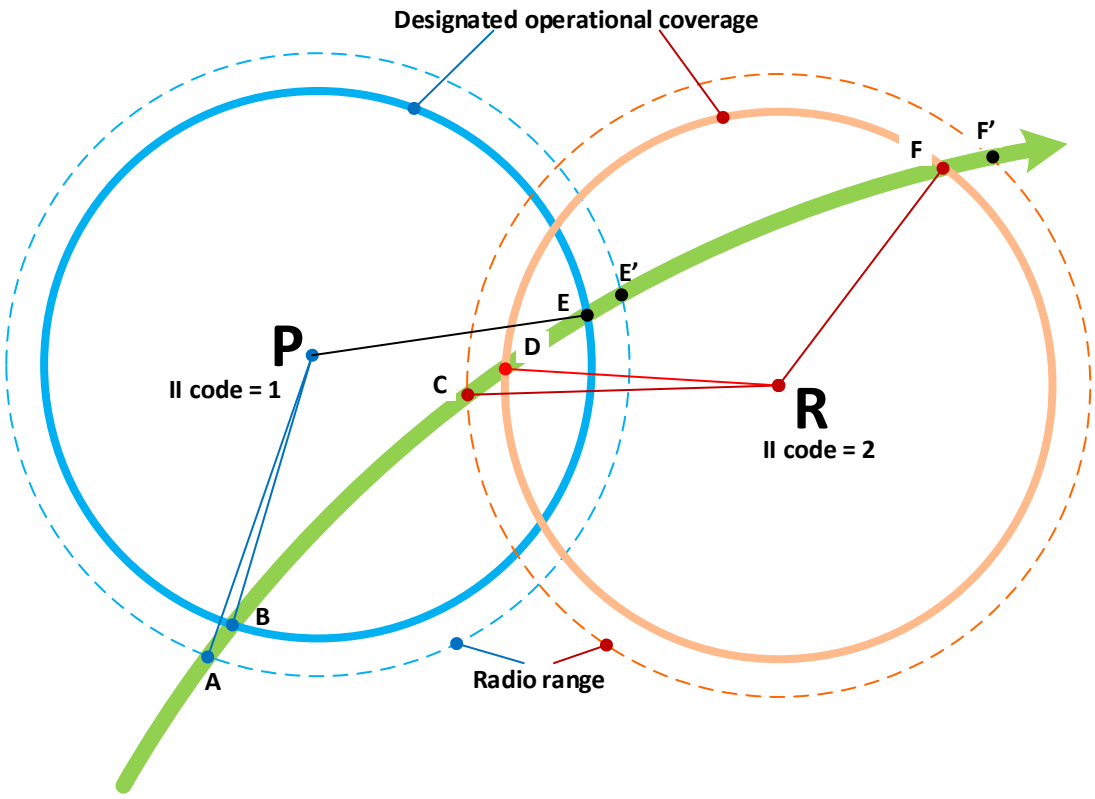
8.3.2 Mode S ground stations with overlapping coverage operating on different interrogator codes

8.3.2.1 In Figure J-19, an aircraft travelling from A to ~~B~~ F' will respond to interrogations of SSR Mode S ground stations (interrogators) P and R as follows:

a) When the aircraft is outside the designated operational coverage of the interrogator P, but is within the (radio) range (point A) where it can receive all-call interrogations from interrogator P, the aircraft transponder will generate an all-call reply. This reply includes the ~~II code~~ interrogator code (II code 01 in this example) of interrogator P and the 24-bit aircraft address. However, as long as the aircraft is outside the designated operational coverage of interrogator P, the interrogator P ~~it~~ will not accept this reply.

b) When the aircraft enters the designated operational coverage of interrogator P (point B), the all-call reply from the aircraft transponder will be accepted by interrogator P and, after two or three scans, a selective interrogation ~~(see 8.2.4 of this appendix)~~ commanding lockout to II=1 will be sent to the aircraft. The aircraft will be added to the list of "acquired aircraft" that is maintained by interrogator P.

Upon reception of this (and any further) selective interrogation (also referred to as roll-call) commanding lockout, the aircraft transponder will not respond to further all-call interrogations from interrogator P (and all-call interrogations from other interrogators that have the same interrogator code ~~identifier code = 1~~).



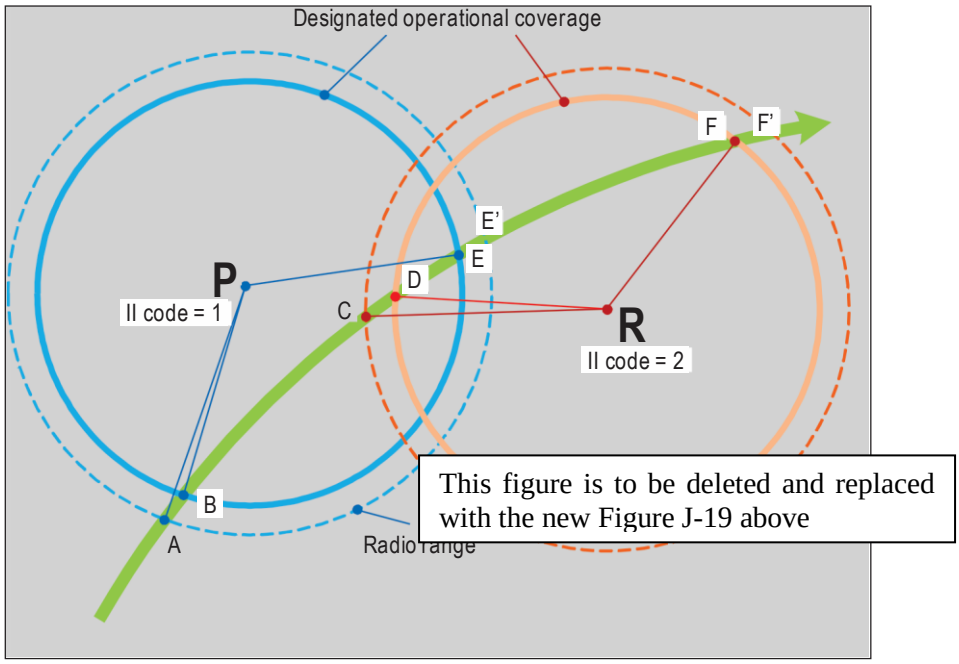


Figure J-19. Process for II (or SI) code acquisition and lockout

c) When the aircraft is outside the designated operational coverage of the interrogator R, but is within the (radio) range (point C) where it can receive all-call interrogations from interrogator R, the aircraft transponder will generate an all-call reply only when the ~~II~~ interrogator code of interrogator R is different from the ~~II~~ interrogator code of interrogator P. This reply includes the 24-bit aircraft address. However, as long as the aircraft is outside the designated operational coverage of interrogator R, the interrogator R will not accept this reply.

Note.— If the ~~II code~~ interrogator code of interrogators P and R are the same, the aircraft will not respond to all-call interrogations of interrogator R.

d) When the aircraft enters the designated operational coverage of interrogator R (point D), the all-call reply from the aircraft transponder will be accepted by interrogator R and a selective interrogation will be sent to the aircraft commanding lockout to the IC of interrogator R (e.g. II=2). After two or three scans, the ~~The~~ aircraft will be added to the list of "acquired aircraft" that is maintained by the interrogator R and selectively interrogated by this interrogator. Upon reception of this (and any further) selective interrogation containing a lockout command ~~for~~ to the IC of interrogator R (e.g. II=2), the aircraft transponder will not respond to further all-call interrogations from interrogator R. The aircraft is now "acquired" by two SSR Mode S ground stations and selectively interrogated independently by each interrogator.

Note.— If the ~~II~~ interrogator code of interrogators P and R are the same, the aircraft will not respond to all-call interrogations of interrogator R and as a result the aircraft will not be identified by interrogator R until it has left the designated operational coverage of interrogator P.

e) When the aircraft is ~~outside~~ leaving the designated operational coverage of interrogator P (point E), interrogator P will no longer selectively interrogate the aircraft, including the lockout command. After a period of 18 seconds the aircraft will lose its lockout status with respect to interrogator P (II=1). Although the aircraft will (resume to) respond to all-calls from interrogator P, as long as the aircraft is within the radio range of interrogator P (until point E'), these replies are not accepted by interrogator P. The aircraft is now only under surveillance by interrogator R.

Note.— If the ~~II~~ interrogator code of interrogators P and R are the same, the aircraft will start responding to all-call interrogations of interrogator R 18 seconds after it has left the designated operational coverage of interrogator P and no longer receives selective interrogations from this interrogator.

Note 2: A buffer zone of 5 NM is used in Mode S IC assignment planning to ensure that the transponder leaving the DOC of an interrogator is not locked-out anymore on its interrogator code when entering the DOC of the next interrogator operating on the same interrogator code. For an aircraft travelling with 500 NM/hr., 18 seconds correspond to about 2.5 NM

f) When the aircraft is outside the designated operational coverage of interrogator R (point F), the interrogator will no longer selectively interrogate the aircraft. After a period of 18 seconds, the aircraft will lose its lockout status with respect to interrogator R (II=2). Although the aircraft will (resume to) respond to all-calls from interrogator R, as long as it is within the radio range of interrogator R (until point F'), these replies are not accepted by interrogator R. The aircraft is now no longer under surveillance by any interrogator.

8.3.3 Clustering of interrogators (ground station networking)

8.3.3.1 SSR Mode S interrogators which have overlapping designated operational coverage can share the same interrogator ~~identifier~~ code in cases where the ground stations are networked and share their tables of acquired aircraft (and in particular the 24-bit aircraft address and the approximate location of the acquired aircraft). In this case, both interrogators P and R in Figure J-20 4 send selective interrogations to the aircraft and obtain valid responses. This process will allow for the use of the same IC (interrogator ~~identifier~~ code) by two (or more) interrogators with overlapping coverage areas. This method is called "clustering"; the group of cooperating ground stations is a "cluster". Two techniques for managing a cluster have been developed:

a) *Distributed clustering* — A "distributed" cluster of interrogators contains a defined number of interrogators which are interconnected. Using coverage maps, each interrogator knows the designated operational ~~range~~ coverage of all other interrogators within its own coverage. Based on this knowledge, tracking support is given to or requested from other interrogators of the cluster.

b) *Central clustering* — A "central" cluster of interrogators is basically the same as a "distributed" cluster, but a cluster controller takes care of supplying the interrogators with needed tracking support and node states. Central clustering has been proved to be more powerful, with higher safety capabilities compared to distributed clustering because of:

— permanent availability and consistency check of the complete air situation;

— possibility of also using non-clustered sensors for tracking support;

— efficient and safe central cluster control capabilities, e.g. use of alternative cluster states on command, enabling, for example, reaction in case of IC conflicts; and

— efficient validation and verification possibilities.

8.3.3.2 The operation of a cluster is illustrated in Figure J-20. At point "C" the transponder in within the radio range of interrogator R but does not reply to the All-Call from interrogator R since the transponder is locked out from responding to All Calls with II code = 01. At point "D", interrogator "R" gets tracking support containing the Mode S address, position and speed vector of the aircraft at a defined time. This defined time is also included within the tracking support. Taking this information, interrogator "R" can calculate when the antenna beam is over the aircraft the next time. Therefore, it is possible to use a selective interrogation directly without having received any all-call reply from that aircraft. The tracking support message can be sent either by:

— interrogator "P" (distributed clustering), or by

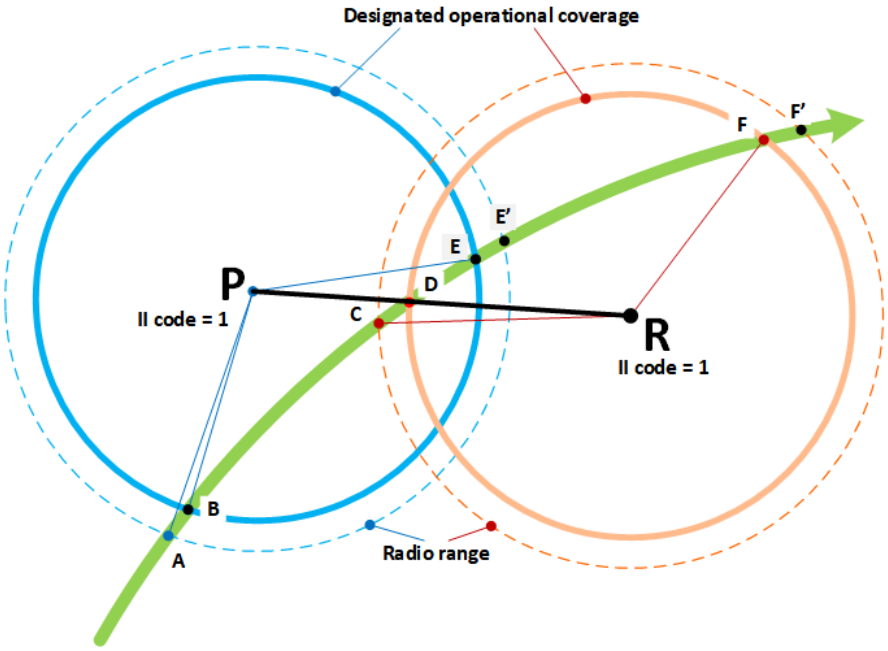
— a cluster controller (central clustering).

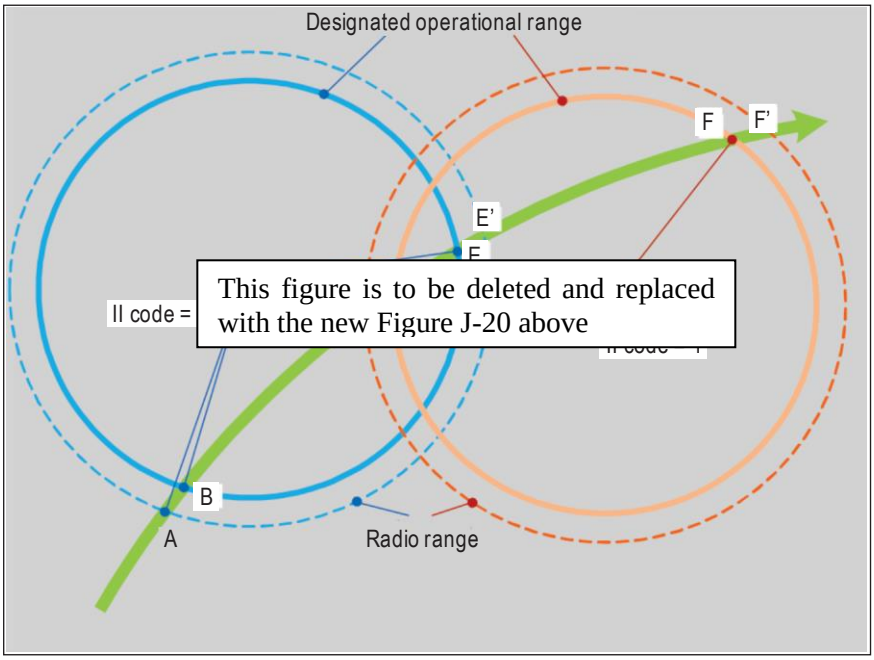
8.3.3.3 In terms of RF channel load optimization, it is very advantageous to assign the same interrogator ~~II~~ code to adjacent non-overlapping radars, since this reduces the FRUIT in the area between the designated operational range and the radio range.

Note.— For additional recommendations and statement of benefits of clustering, see Appendix J, 4.4.4, Appendix M, 1.10, and Appendix M, 12.2.1.

~~8.3.4 Techniques for managing overlapping coverage~~

~~8.3.4.1 Using multiple interrogator codes by a single Mode S ground station.~~





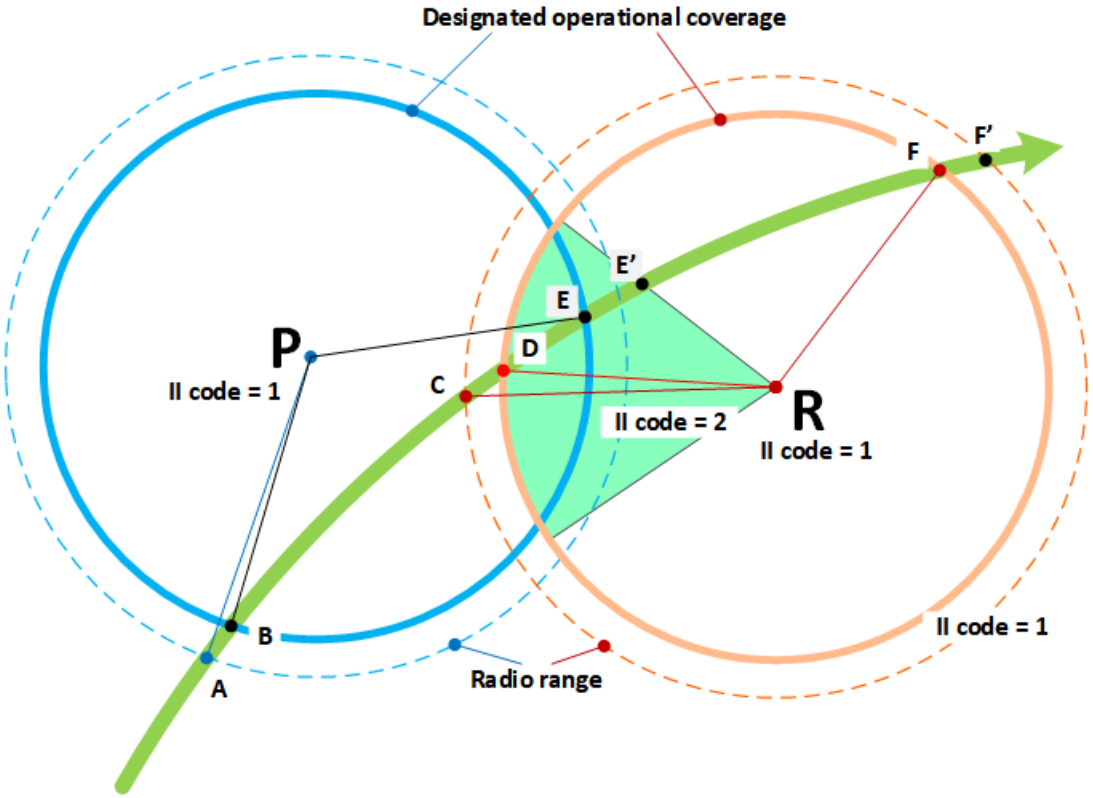
This figure is to be deleted and replaced with the new Figure J-20 above

Figure J-20. SSR Mode S interrogator clustering (interrogators with same ~~II~~ interrogator code)

8.3.4 Other techniques for managing requests with overlapping coverage

8.3.4.1 Using multiple interrogator codes by a single Mode S ground station.

8.3.4.1.1 Another method for improving the efficient use of ~~II~~ interrogator codes is using two (or more) interrogator ~~II~~ codes by a single interrogator. In this method, different sectors of the interrogator can be assigned different interrogator ~~II~~ codes. The sector that overlaps with another interrogator will have a different interrogator ~~II~~ code, while the parts of the coverage not overlapping can have the same interrogator ~~II~~ code. However, it is recommended to use the minimum possible number of interrogation ~~identifiers~~ codes by one single Mode S ground station. Figure J-21 gives an example of sectorized use of ~~II~~ interrogator codes by a single interrogator.



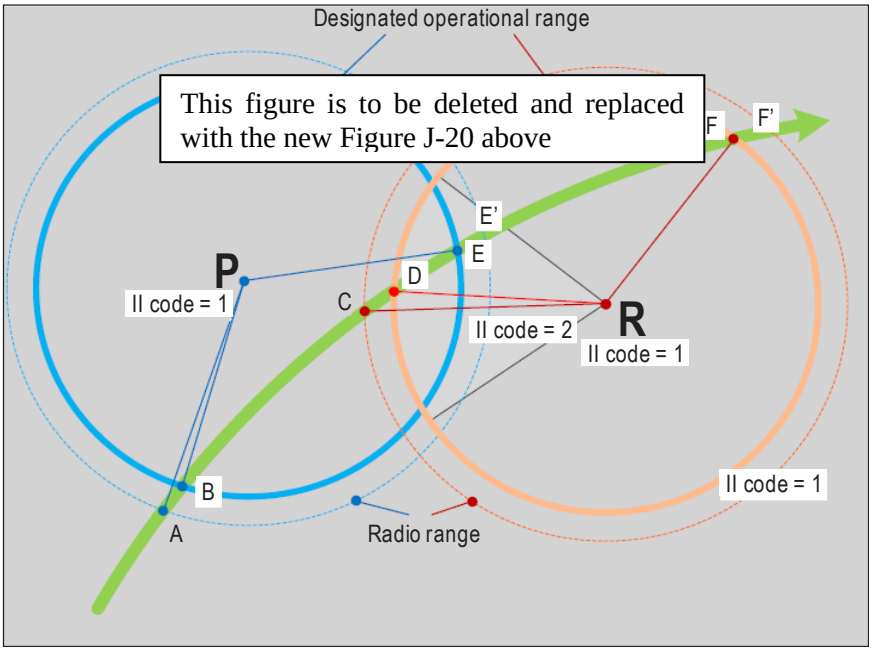


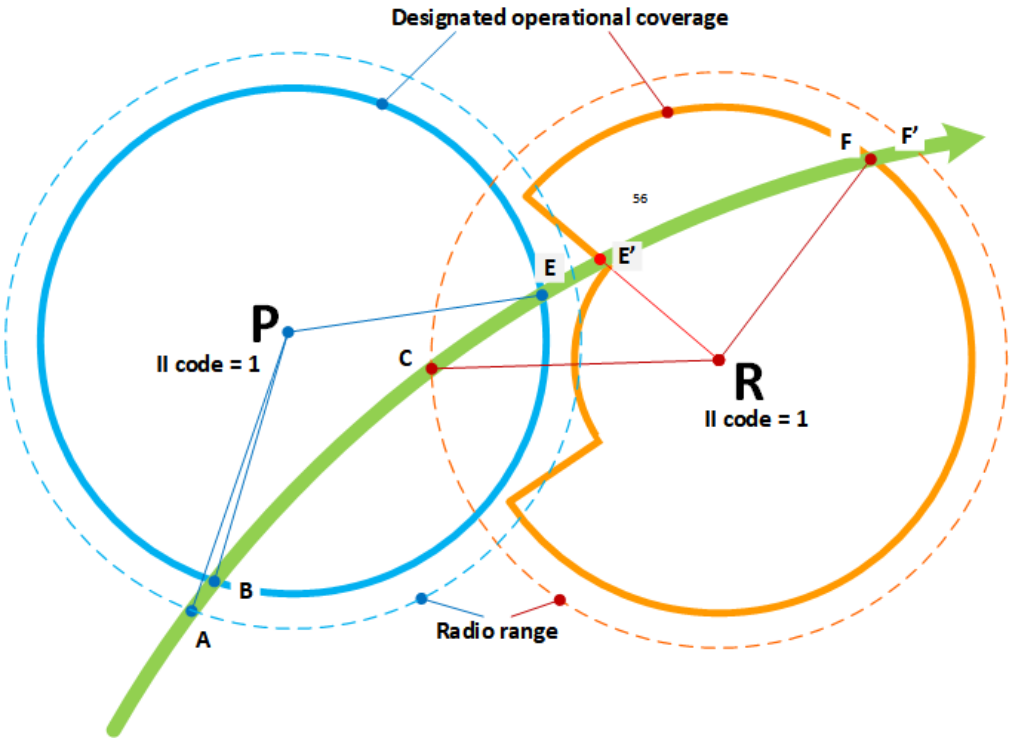
Figure J-21. ~~Sectorized use of II codes~~ Multiple ICs used by a single Mode S ground station

8.3.4.1.2 At the point E' in Figure J-21 that aircraft is losing the acquired status with interrogator R on II=02 and acquired by interrogator R with the II=01

8.3.4.2 Define the maximum designated operational ~~range~~ coverage on a sector basis (Re. Figure J-22).

8.3.4.2.1 In some cases, adjacent SSR Mode S ground stations may have limited overlapping coverage areas. In addition, the Mode S ground stations may not require a circular coverage and the designated operational range can be specified with a different range in different sectors. In this case, it is possible to use the same interrogator ~~II~~ code for both ground stations if the designated operational ~~range~~ coverage of one or both of the ground stations is reduced in the sector of the overlap. The net effect of the range reduction is to eliminate the overlap of the DOC. Figure J-22 gives an example of the use of sectored range reduction for one interrogator to eliminate overlap. This range reduction can also be achieved using a coverage map defining a common grid. ~~In this case, the process consists of specifying an II code for a given area in which this II code can be used for lockout.~~
This technique can be applied with Method A as further defined in paragraph 8.4.3.1, and with Method B as further defined in paragraph 8.4.4.1 and paragraph 8.4.4.2.

~~8.3.5 The above examples illustrate the need for SSR Mode S ground stations, which have overlapping coverage, to be assigned a unique Mode S IIinterrogator code, except in the case where SSR Mode S ground stations are clustered, as described in 8.3.3 of this appendix Appendix.~~



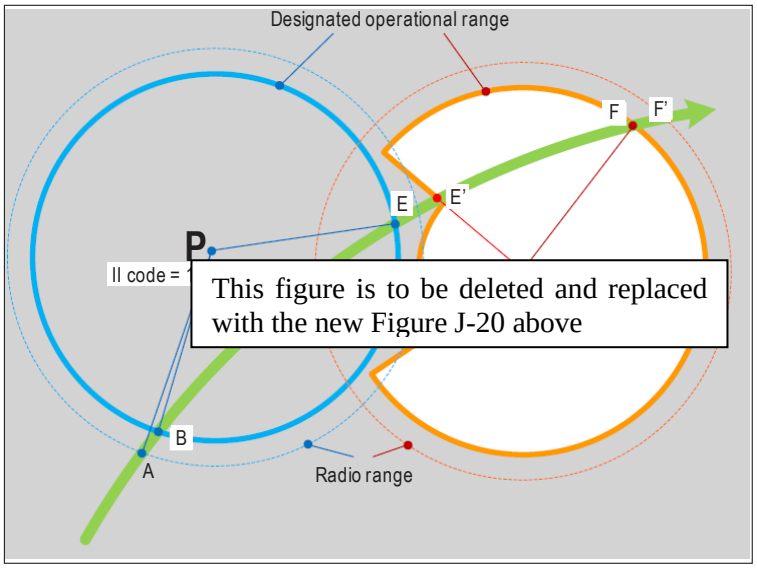


Figure J-22. Sectorized maximum range

8.3.4.3 Lockout override (Re. Figure J-23)

8.3.4.3.1 The DOC of both interrogators, operating with the same IC (II=01) are circular and overlapping. In the volume of airspace where the DOC of both interrogators are overlapping, the Mode S aircraft transponders are locked out on the IC used by both interrogators, preventing them to respond to the all-call interrogations from both interrogators. Therefore, aircraft cannot be acquired in the volume where DOCs are overlapping. Lockout override can be used by both interrogators in the sector where DOCs are overlapping to force the aircraft transponders to reply to the all-call interrogations on II 01, meaning that the aircraft transponders can be acquired in the volume where DOCs are

overlapping. However, as explained in 8.2.6.7.1.2, this technique will result in an increase of all-call replies and potential garbling in the sectors where lockout override is applied and is therefore not recommended. Once acquired, the transponders are selectively interrogated by each interrogator in the volume where DOCs are overlapping.

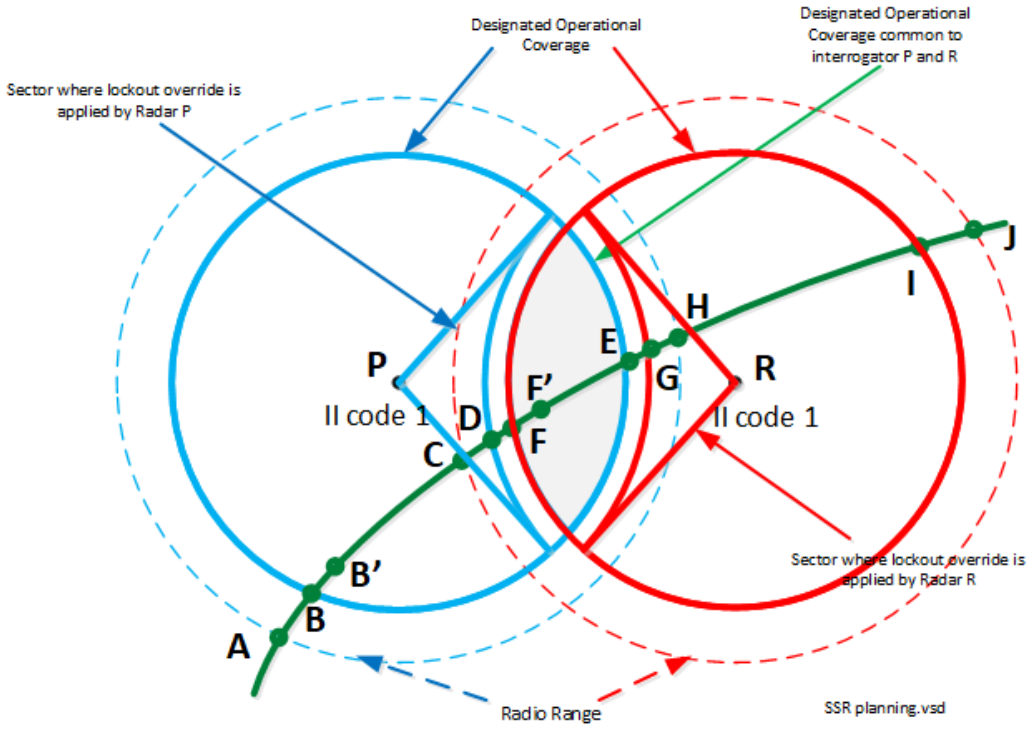


Figure J-23. Lockout override

a) When the aircraft is outside the DOC of the interrogator P but is within the (radio) range (point A in Figure J-23) where it can receive all-call interrogations from interrogator P, the aircraft transponder replies to the all-call interrogations. However, as long as the aircraft is outside the DOC of interrogator P, the interrogator does not accept the replies.

b) When the aircraft enters the DOC of interrogator P (point B in Figure J-23), the all-call replies from the aircraft transponder are accepted by interrogator P. After two or three scans, the aircraft transponder is acquired and selectively interrogated by interrogator P (point B' in Figure J-23). The aircraft is added to the list of "acquired aircraft" that is maintained by interrogator P. Upon reception of these selective interrogations (Roll Calls) which include a lockout command the aircraft transponder will not respond to further all-call interrogations on the IC of interrogator P (II=01 in this example).

c) When the aircraft is outside the coverage of the interrogator R, but within the (radio) range where it can receive all-call interrogations on II=01 from interrogator R, the aircraft transponder does not reply because it is locked on II=01 by interrogator P, except if the aircraft is inside the sector where lockout override is applied by interrogator R. In point C of Figure J-23, the aircraft is inside the sector where lockout override is applied by interrogator R and therefore replies to all-call interrogations on II=01. It will reply to all-call interrogations from interrogator R as long as it is in the lockout override sector and within the radio range of interrogator R (until a bit before Point H in Figure J-23 where it leaves the lockout override sector).

Very shortly after point C in Figure J-23, the aircraft enters in the sector where lockout override is applied by interrogator P, and will also respond to all-call interrogations of interrogator P. It will reply

to all-call interrogations from interrogator P as long as it is in the lockout override sector and within the radio range of interrogator P (until a bit before Point H in Figure J-23 where it leaves the radio range).

e) When the aircraft enters the DOC of interrogator R (point F in Figure J-23) the aircraft is still locked on II=01 . However, it replies to all-call interrogations on II=01 because it is inside the sector where lockout override is applied by interrogator R. Therefore, the aircraft can be acquired and selectively interrogated (Roll Call with lockout command) by interrogator R at point F' in Figure J-23. However, in point F and F', the aircraft is inside the sectors where lockout override is applied by interrogator P and R, and therefore responds to all-call interrogations for both interrogators.

f) When the aircraft leaves the DOC of interrogator P (point E in Figure J-243), the interrogator P stops sending selective interrogations to the aircraft. The aircraft still replies to all-call interrogations from interrogator P because it is inside the sector where lockout override is applied by interrogator P, and within its radio range.

h When the aircraft leaves the radio range of interrogator P, the aircraft stop replying to all-call interrogations from interrogator P.

The aircraft has replied to all-call interrogations from interrogator P and R from (almost) point C to (almost) point H in Figure J-23. This mode of operation should be used with care because increasing the RF pollution.

i) When the aircraft leaves the DOC of interrogator R (point I in Figure J-23), the interrogator stops sending Roll Calls to the aircraft. After a period of 18 seconds the aircraft will lose its lockout status and will reply to any all-call interrogation on IC = II 01.

j) The aircraft will respond to all-call interrogations from interrogator R as long as it is within the radio range of interrogator R (until point J in Figure J-23). These replies are not accepted by interrogator R.

8.4 Practical examples of interrogator identifier code assignments

8.4.1 Figure J-2324 provides an example of assigned interrogator identifier codes for Mode S interrogators with overlapping coverage areas. In the areas of overlap, the aircraft responds to all-call interrogations and selective interrogations from more than one ground station, as indicated.

8.5 Planning parameters for SSR Mode S ground stations

8.5.1 All SSR Mode S interrogators have a maximum operational range within which surveillance service will be offered to aircraft. This maximum range is determined by operational considerations and is referred to as designated operational ~~range~~ coverage (DO~~R~~C). This DO~~R~~C can be simply defined by a single range valid for all azimuths, by different ranges for different azimuth sectors or by a more complex coverage map indicating where the ground station will selectively interrogate and lock out aircraft. When the aircraft is within the radio range of the interrogator, but outside the designated operational ~~range~~ coverage, the aircraft will reply to all-call interrogations from the interrogator. These replies will ~~be~~ not be accepted by the interrogator after it has determined that the aircraft is outside the designated operational ~~range~~ coverage.

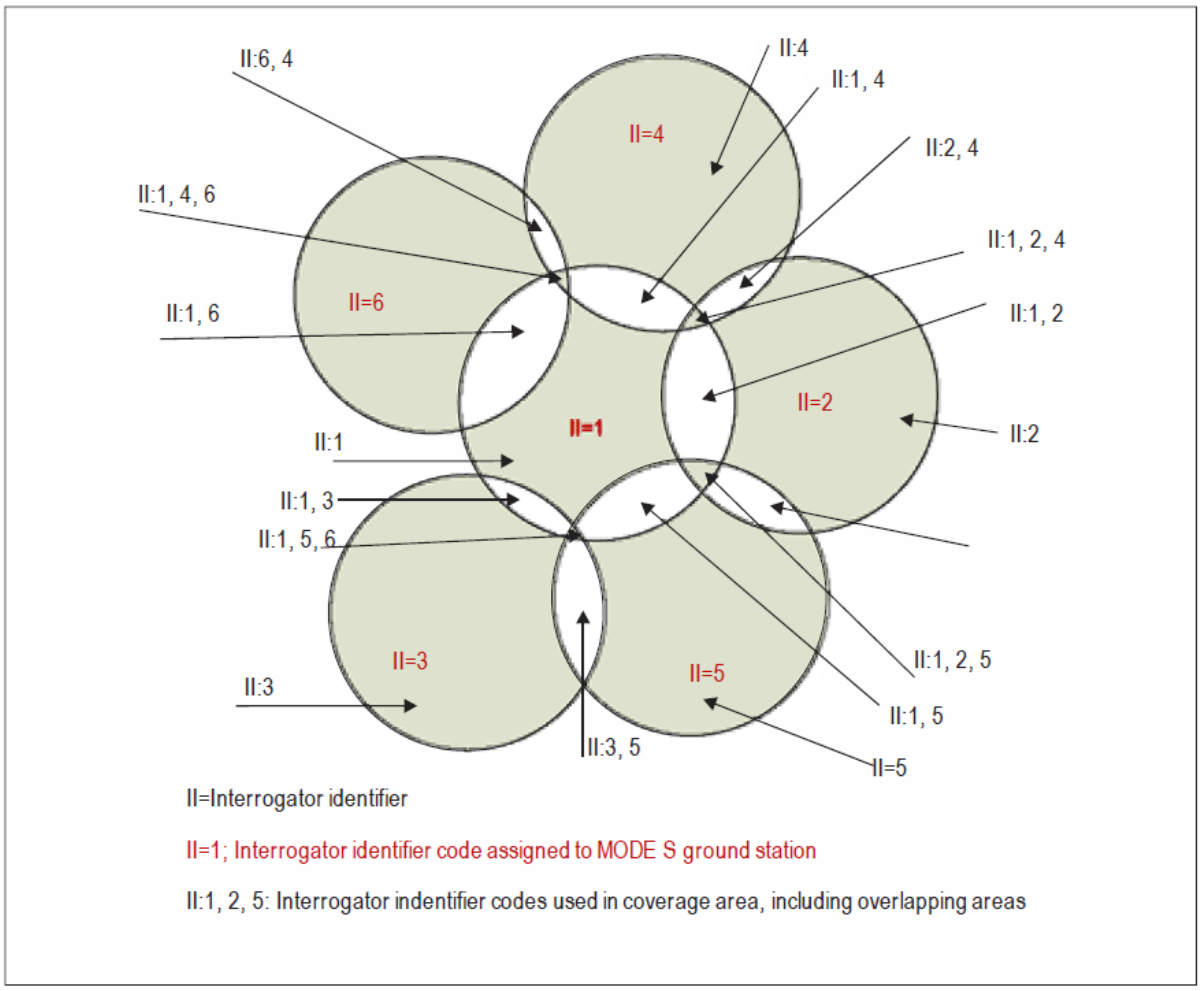


Figure J-~~23~~24. Example of II code assignments

8.5.2 SSR Mode S ground stations with the same ~~II~~ interrogator code

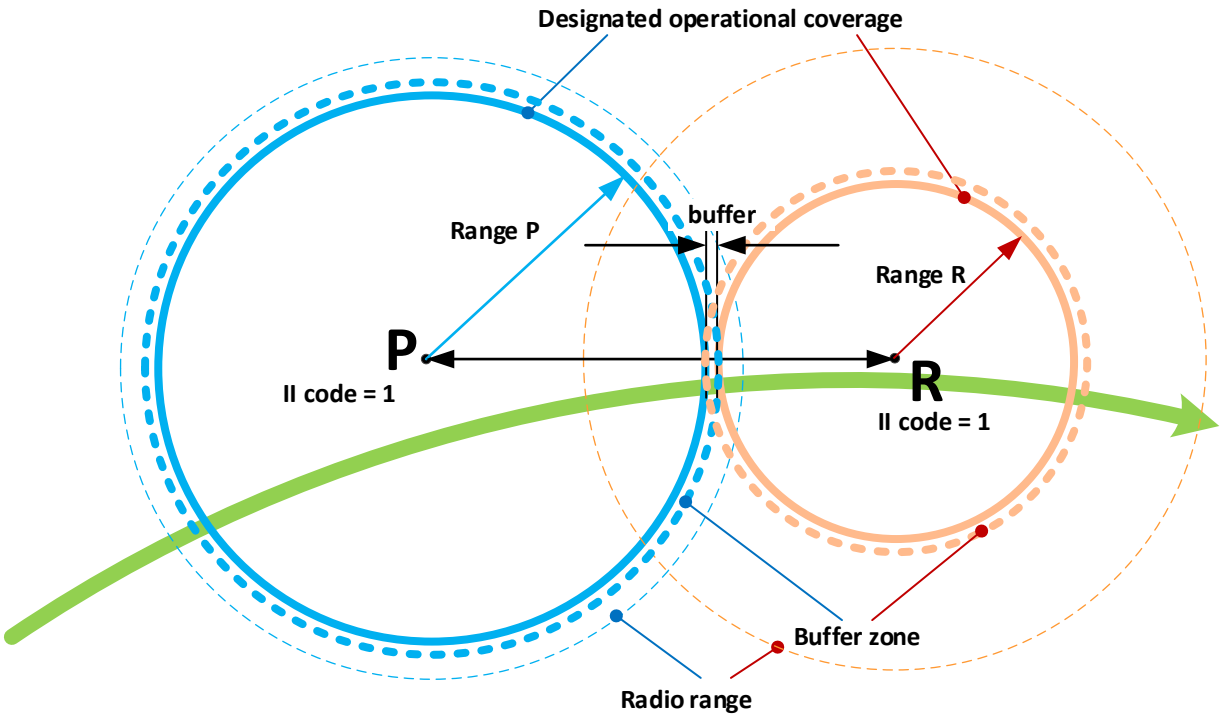
8.5.2.1 To be acquired by a Mode S ground station, an aircraft must not be locked-out by another Mode S ground station operating on the same interrogator code (except in case of ground coordination between Mode S ground stations, i.e., Mode S ground stations operating in cluster, or if lockout override is applied). Therefore, an aircraft must not be locked-out on the interrogator code of a Mode S ground station when entering in its DOC. Considering that there is a timer of 18 seconds on the aircraft lockout state, a buffer zone where the aircraft does not receive lockout request is required to ensure the aircraft is no longer locked-out when entering in the DOC.

8.5.2.2 There are two methods to implement a buffer zone to ensure that aircraft are not locked-out when entering the DOC of a Mode S ground station:

a) Method A – external buffer method: by ensuring there is a buffer zone implemented around the DOC of Mode S ground stations operating on the same interrogator code. In this case, lockout can be applied in the entire DOC and DOCs are not contiguous. The aircraft will become unlocked while traversing the buffer zone around the DOC.

b) Method B – internal buffer method: by ensuring an aircraft is unlocked when leaving the DOC of a Mode S ground station. In this case a buffer zone is implemented within the DOC, meaning that lockout is applied in a volume of airspace smaller than the DOC to ensure that the aircraft will be unlocked when leaving the DOC.

8.5.2.~~3.1~~ With Method A (external buffer method), as ~~As~~ shown in Figure J-~~24~~25, the minimum geographical separation between two SSR Mode S interrogators, which have been assigned the same ~~II~~interrogator code, is the sum ~~or~~ of the respective designated operational range for each interrogator, plus a buffer zone. The buffer zone should be large enough to enable the aircraft to time out of its lockout status for all-call interrogations, plus a margin that would cater for certain processing delays. The aircraft transponder cancels its lockout status for all-call interrogations if, for a period of 18 seconds, no selective interrogation with a lockout command has been received. For an aircraft travelling at a speed of 600 NM/hr, this would be equal to 3 NM. For example, a buffer zone of ~~10~~ 5 NM is adequate to ensure that an incoming aircraft will be unlocked when it enters the operational coverage area of the next interrogator.



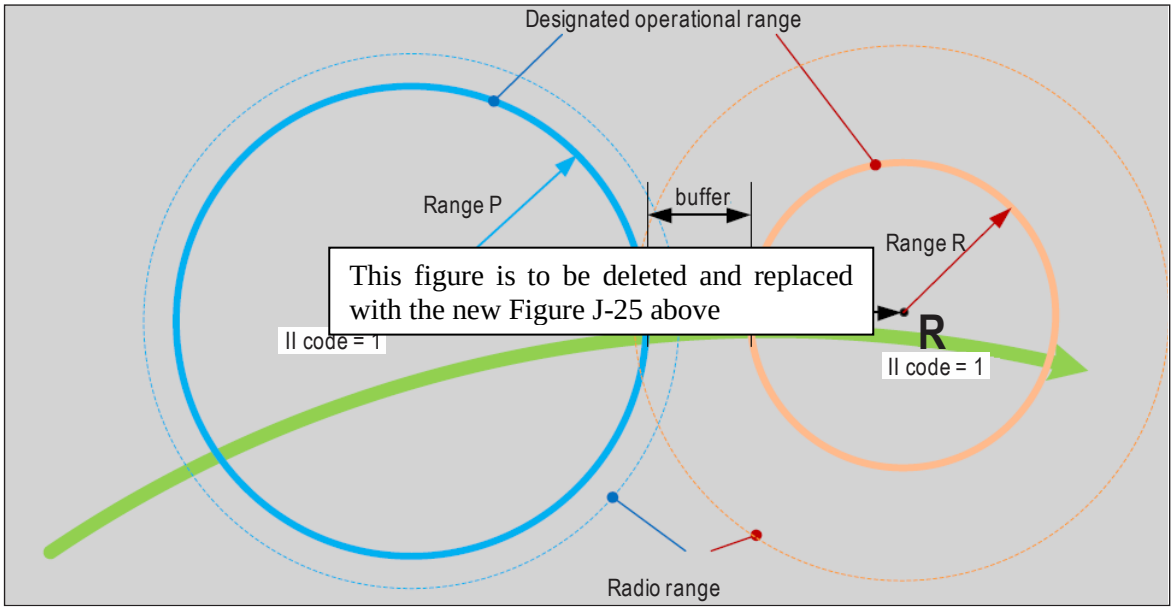


Figure J-~~24~~25. Minimum separation distance between interrogators having the same II code

~~8.5.2.2~~ The minimum separation distance between two SSR Mode S interrogators with the same ~~II~~interrogator code as shown in Figure J-~~24~~25 is:

Range P + ~~10~~ 5 NM + range R

Where 5 NM is the distance necessary for a transponder to become unlocked after is no longer receives a lockout command. Most SSR Mode S implementations use a lockout coverage that is the same as the DOC.

This method does not allow the tracking of aircraft by Mode S ground stations using the same interrogator code in the buffer zone.

8.5.2.4 When using Method B (internal buffer method), as shown in Figure J-26, there is no need to apply a buffer zone outside the DOCs of Mode S ground stations which can therefore be contiguous. The lockout coverage needs to be specified as a sub-volume of the DOC. The lockout coverage needs to be defined separately as lockout is not applied in the full DOC. The lockout coverage is typically 5NM smaller than the DOC which corresponds in this method to the surveillance coverage. In the Figure J-26 below, the coverages are defined in a common grid specified in a global WGS-84 system of coordinates.

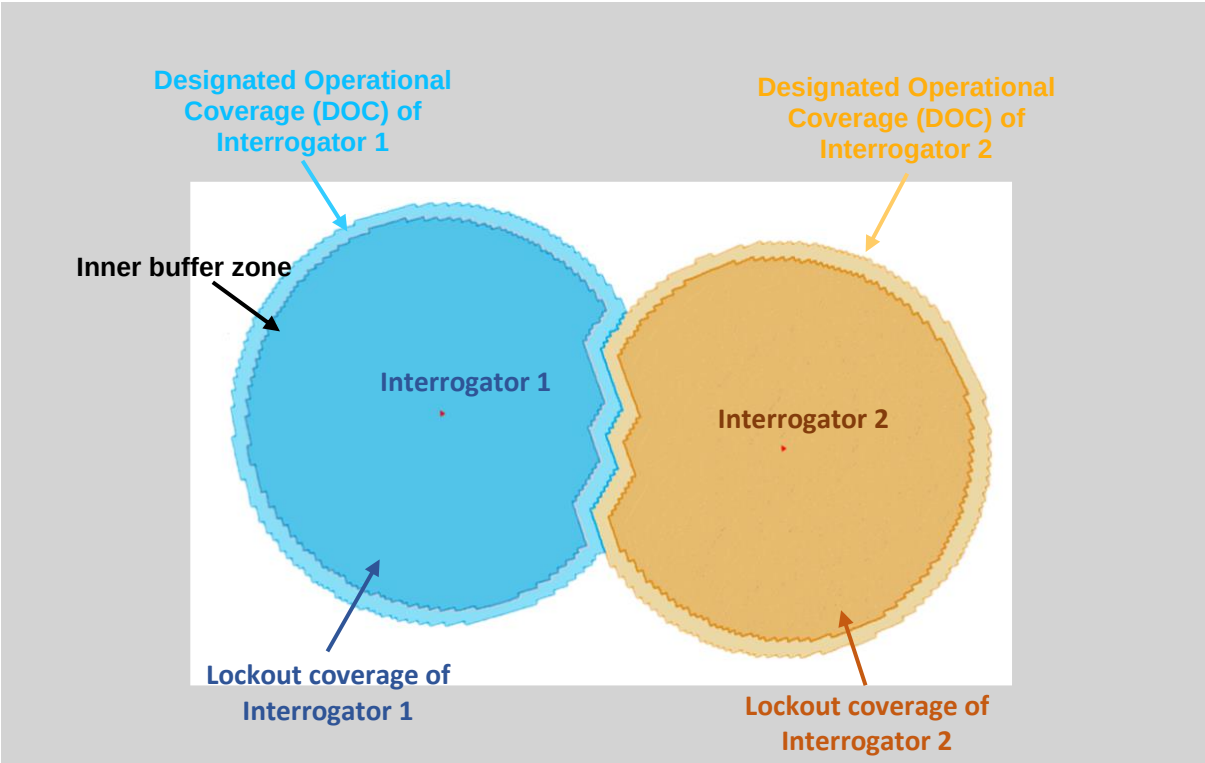


Figure J-26. DOC internal buffer method applied to interrogators having the same IC

This method enables the continuous tracking of aircraft by Mode S ground stations having contiguous DOC on the same interrogator code, at the expense of more all-call replies as the internal buffer zone is equivalent to 10NM (2 x 5NM)

8.5.2.5 The two methods, Method A and Method B, are interoperable and can be mixed, as shown in Figure J-27. Therefore, different methods can be used in two adjacent ICAO Regions. Tools using the Method A (external buffer method*)* can accommodate Mode S radar whose the IC assignment has been performed using Method B (internal buffer method*)* because it applies an additional buffer outside the DOC. For the coordination between adjacent ICAO regions using different methods, Method A (external buffer method*)* should be used.

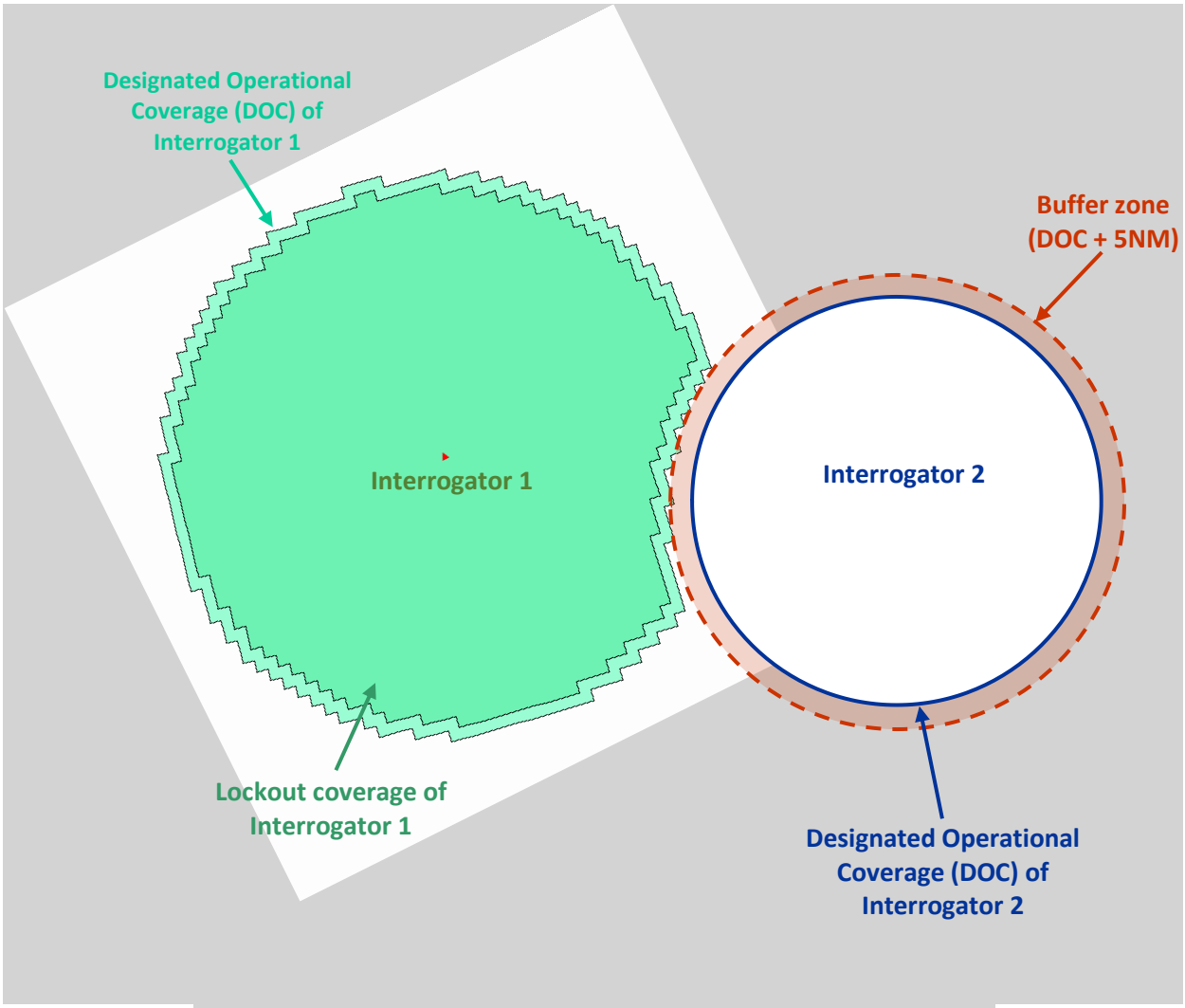


Figure J-27. Method A and B applied to interrogators having the same IC

8.4.3 Techniques for managing overlapping coverage with Method A.

8.5.3.1 Reduced designated operational coverage on a sector basis.

8.5.3.1.1 This method has already been presented in paragraph 8.3.4.2 from a generic perspective. It is further defined below considering that Method A (external buffer method) is programmed in the Mode S ground stations.

8.5.3.1.2 In some cases, adjacent SSR Mode S interrogators may not require circular coverage and the DOC can be specified with a different range in different sectors. In this case, it is possible to use the same IC for both (nearby) interrogators if the range of the DOC of one (or both) of the interrogators is reduced in the sector of the overlap in order to eliminate the overlap of the DOCs. Figure J-28 gives an example of the use of DOC reduced by sector for one interrogator to eliminate overlap. A buffer zone of 5 NM between DOC of interrogators needs to be applied in Method A to ensure that an aircraft transponder leaving the DOC of an interrogator is no longer locked-out when entering in the DOC of the next interrogator operating on the same interrogator code. For an aircraft travelling with 500 NM/hr., 18 seconds correspond to about 2.5 NM.

8.5.3.1.3 In Figure J-28, an aircraft travelling from A to G will respond to interrogations of SSR Mode S ground stations (interrogators) P and R as follows:

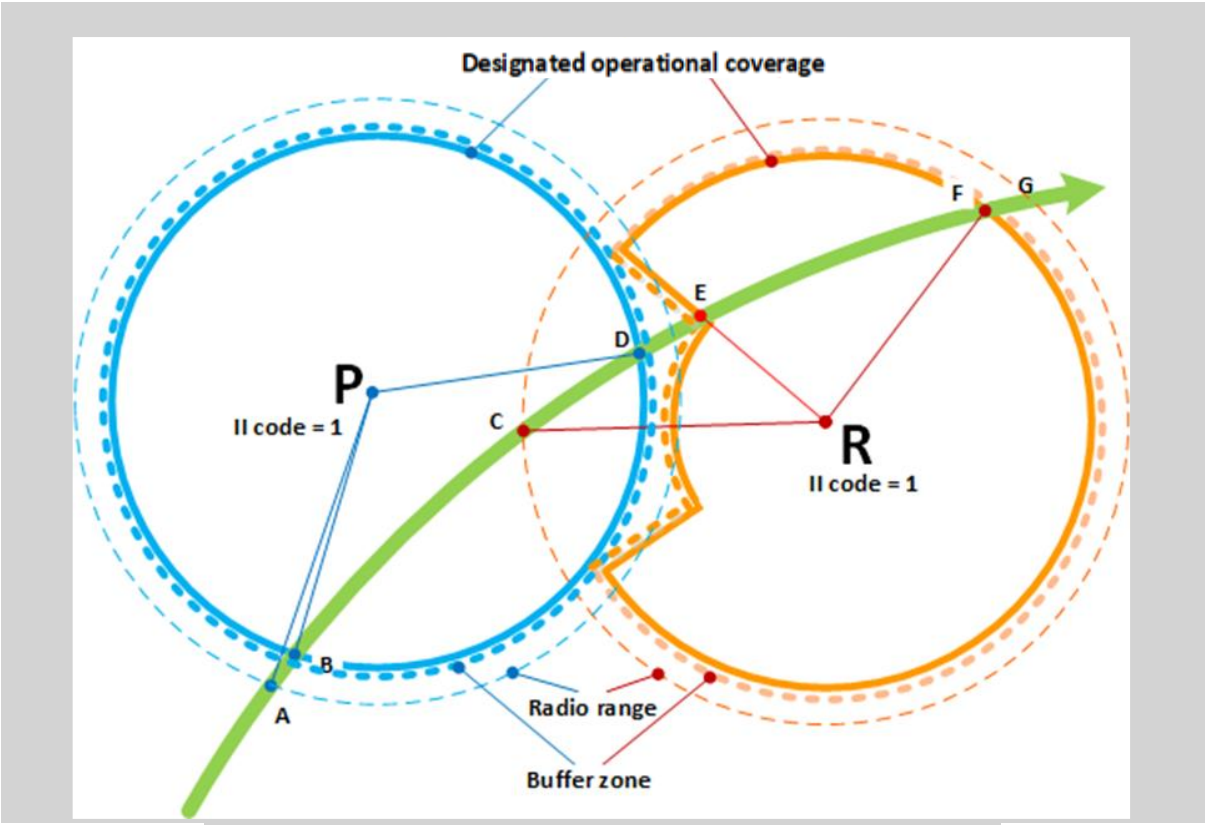


Figure J-28. Sectorized designated operational coverage (Method A)

a) When the aircraft is outside the DOC of the interrogator P but is within the radio range (point A) where it can receive all-call interrogations from interrogator P, the aircraft transponder replies to the all-call interrogations. The replies contain the IC of interrogator P (II=01 in this example) and the 24-bit aircraft address. However, as long as the aircraft is outside the DOC of interrogator P, the interrogator does not accept the replies.

b) When the aircraft enters the DOC of interrogator P (point B), the all-call replies from the aircraft transponder are accepted by interrogator P. After two or three scans the aircraft is acquired and selectively interrogated by interrogator P. The aircraft will be added to the list of “acquired aircraft” that is maintained by interrogator P. The selective interrogations (Roll-Call) include a lockout command for the IC of interrogator P (II=01 in this example). Upon reception of these selective interrogations, which include a lockout command, the aircraft transponder will not respond to further all-call interrogations from interrogator P and to all-call interrogations from other interrogators that have the same interrogator code (II=01 in this example).

c) When the aircraft is outside the coverage of the interrogator R, but within the radio range (point C) where it can receive all-call interrogations on II=01 from interrogator R, the aircraft transponder does not reply because it is locked out on II=01 by interrogator P.

d) When the aircraft leaves the DOC of interrogator P (point D), the interrogator does no longer send selective interrogations to the aircraft (and therefore no longer lockout commands). Then the aircraft enters in the buffer zone. After a period of 18 seconds while traversing the buffer zone, the aircraft will lose its lockout status with respect to interrogator P (II=1) and will start to reply to all-call interrogations received from interrogators P and R on II=01.

Note : A buffer zone of 5 NM between DOC of interrogators is used in Method A for Mode S IC assignment planning to ensure that an aircraft transponder leaving the DOC of an interrogator is no

longer locked-out when entering in the DOC of the next interrogator operating on the same interrogator code. For an aircraft travelling with 500 NM/hr., 18 seconds correspond to about 2.5 NM

e) When the aircraft enters the DOC of interrogator R whose the range has been reduced per sector (Point E), the aircraft is expected to be unlocked on II=1. From this point onwards, the replies from the aircraft to the all-call interrogations of interrogator R are accepted by interrogator R and, after two or three scans, the aircraft is acquired and selectively interrogated (including a lockout command). Upon reception of these selective interrogations, which include a lockout command, the aircraft transponder will not respond to further all-call interrogations on II=01.

f) When the aircraft leaves the DOC of interrogator R (point E), the interrogator stops sending selective interrogation (Roll Calls) to the aircraft. Then the aircraft enters in the buffer zone. After a period of 18 seconds within the buffer zone the aircraft will lose its lockout status and will reply to all-call interrogations on II=01.

g) The aircraft will respond to all-call interrogations from interrogator R as long as it is within the radio range of interrogator R (until point G). These replies are not accepted by interrogator R.

8.5.4 Techniques for managing overlapping coverage with Method B.

8.5.4.1 Designated operational coverage and lockout coverage reduction on WGS-84 grid

8.5.4.1.1 In some cases, adjacent SSR Mode S ground stations may have limited overlapping coverage areas. In that case, it is possible to use the same interrogator code for both ground stations if the designated operational coverage (DOC, also referred to as surveillance coverage in Method B) and the lockout coverage of one or both ground stations are reduced in the overlapping region.

8.5.4.1.2 In Figure J-29, the coverages are defined in a common grid specified in a global WGS-84 system of coordinates. The DOCs of both Mode S ground stations are reduced to avoid that coverages overlap. In addition, the lockout coverages are further reduced (typically by 5 NM compared to the DOC) to create an internal buffer between the DOC and the lockout coverage to ensure that the aircraft leaving the DOC of the first Mode S ground station is unlocked while entering the DOC of the next Mode S ground station (and can be acquired by the next Mode S ground station).

8.5.4.1.3 In Figure J-29, an aircraft travelling from A to J will respond to interrogations of SSR Mode S ground stations (interrogators) P and R as follows:

a) When the aircraft is outside the surveillance coverage (DOC) of the Mode S ground station P but is within the radio range (point A) where it can receive all-call interrogations from ground station P, the aircraft transponder replies to the all-call interrogations. The replies contain the IC of ground station P (II=01) and the 24-bit aircraft address. However, as long as the aircraft is outside the surveillance coverage of ground station P, the ground station does not accept the replies.

b) When the aircraft enters the surveillance coverage of ground station P (point B), the all-call replies from the aircraft transponder are accepted by ground station P. Then the aircraft is acquired and selectively interrogated by ground station P. The aircraft will be added to the list of “acquired aircraft” that is maintained by ground station P.

c) When the aircraft enters the lockout coverage of ground station P (point C), the ground station P sends selective interrogations commanding lockout to II=01 to the aircraft. Upon reception of these selective interrogation commanding lockout, the aircraft transponder will not respond to further all-call interrogations from ground station P and to all-call interrogations from other ground stations that are operating on the same interrogator code (II=01 in this example).

d) When the aircraft is outside the surveillance coverage of the ground station R, but within the radio range (point D) where it can receive all-call interrogations on II=01 from ground station R, the aircraft

transponder does not reply because it is locked on II=01 by ground station P.

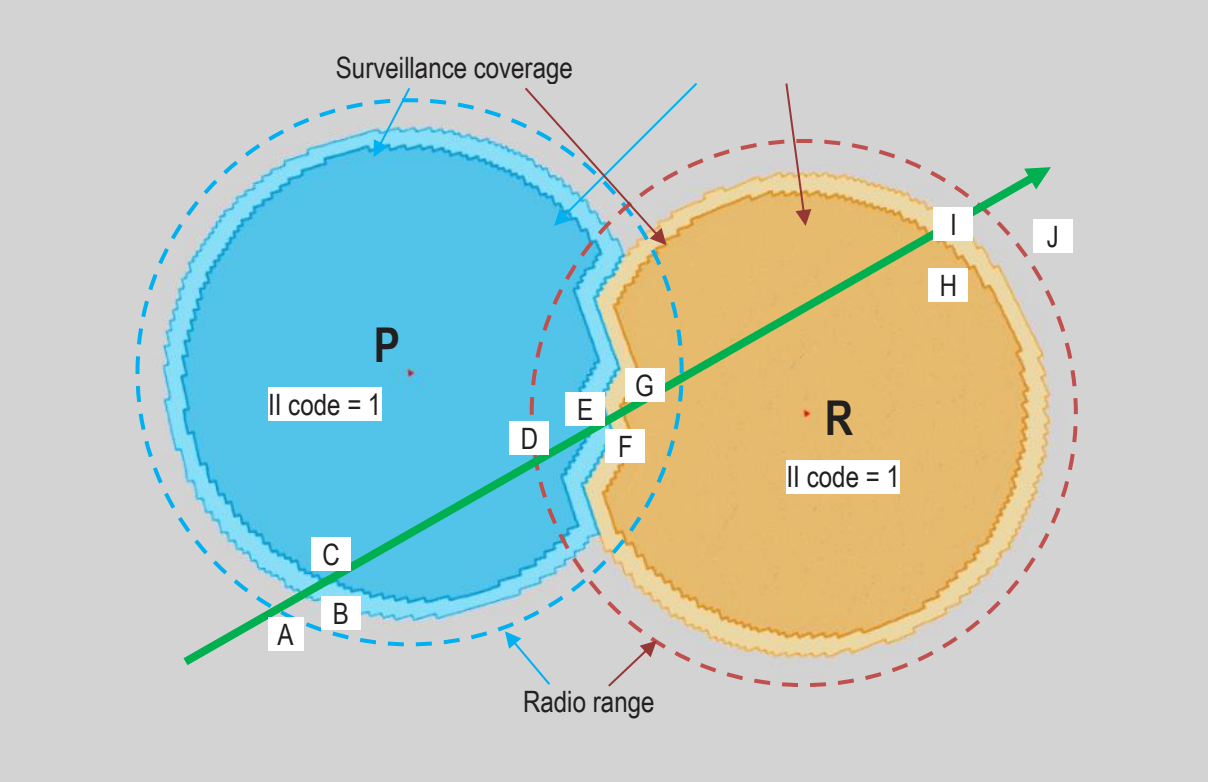


Figure J-29. Surveillance and lockout coverage reduction

e) When the aircraft leaves the lockout coverage of ground station P (point E), the ground station keeps on sending selective interrogation to the aircraft but without lockout request on II=01. After a period of 18 seconds the aircraft will lose its lockout status on II=01 and will reply to all-call interrogations received from ground stations P and R on II=01.

f) When the aircraft leaves the surveillance coverage of ground station P (point F), the ground station P stop sending selective interrogations to the aircraft. At the same time the aircraft enters the surveillance coverage of ground station R. Considering the internal buffer between the surveillance coverage and lockout coverage of ground station P (typically 5 NM), the aircraft is expected to be unlocked on II=01 when entering the surveillance coverage of ground station R. Therefore, the aircraft is expected to reply to all-call interrogations from ground station R on II=01, then be acquired and selectively interrogated by ground station R.

g) When the aircraft enters the lockout coverage of ground station R (point G), the ground station sends selective interrogation commanding lockout on II=01 to the aircraft. Upon reception of these selective interrogations commanding lockout, the aircraft transponder will not respond to further all-call interrogations on II=01.

h) When the aircraft leaves the lockout coverage of ground station R (point H), the ground station keeps on sending selective interrogation to the aircraft but without lockout request on II=01. After a period of 18 seconds the aircraft will lose its lockout status on II=01 and will reply to all-call interrogations on II=01.

i) When the aircraft leaves the surveillance coverage of ground station R (point I), the ground station R stop sending selective interrogations to the aircraft.

j) The aircraft will respond to all-call interrogations from ground station R as long as it is within the radio

range of ground station R (until point J). These replies are not accepted by ground station R.

Note 1: In the example above, the surveillance coverage and lockout coverage of both ground stations have been reduced. Another possibility would have been to further reduce the surveillance and lockout coverage of one ground station, and not to reduce the surveillance coverage of the other ground station.

Note 2: It is always necessary to reduce the lockout coverages (typically by 5 NM compared to the surveillance coverage) to create an internal buffer between the surveillance and lockout coverages to ensure that the aircraft leaving the surveillance coverage of the first ground station is unlocked while entering the surveillance coverage of the next ground station operating on the same IC, and can be acquired by the next ground station.

8.5.4.2 Reduced designated operation coverage and lockout coverage on a sector basis.

8.5.4.2.1 This method has already been presented in paragraph 8.3.4.2 from a generic perspective. It is further defined below considering that Method B (internal buffer method) is programmed in the Mode S ground stations.

8.5.4.2.2 In some cases, adjacent SSR Mode S interrogators may not require circular coverage and the DOC can be specified with a different range in different sectors. In this case, it is possible to use the same IC for both (nearby) interrogators if the range of the DOC of one (or both) of the interrogators is reduced in the sector of the overlap in order to eliminate the overlap of the DOCs. In Figure J-30, the coverages are defined in range per sector. The DOC (also referred to as surveillance coverage in Method B) of one Mode S ground stations is reduced per sector to avoid that coverage overlaps. The lockout coverages are further reduced (typically by 5 NM compared to the DOC) to create an internal buffer between the DOC and the lockout coverage to ensure that an aircraft leaving the DOC of the first Mode S ground station is unlocked while entering the DOC of the next Mode S ground station operating on the same interrogator code, and therefore can be acquired by the next Mode S ground station.

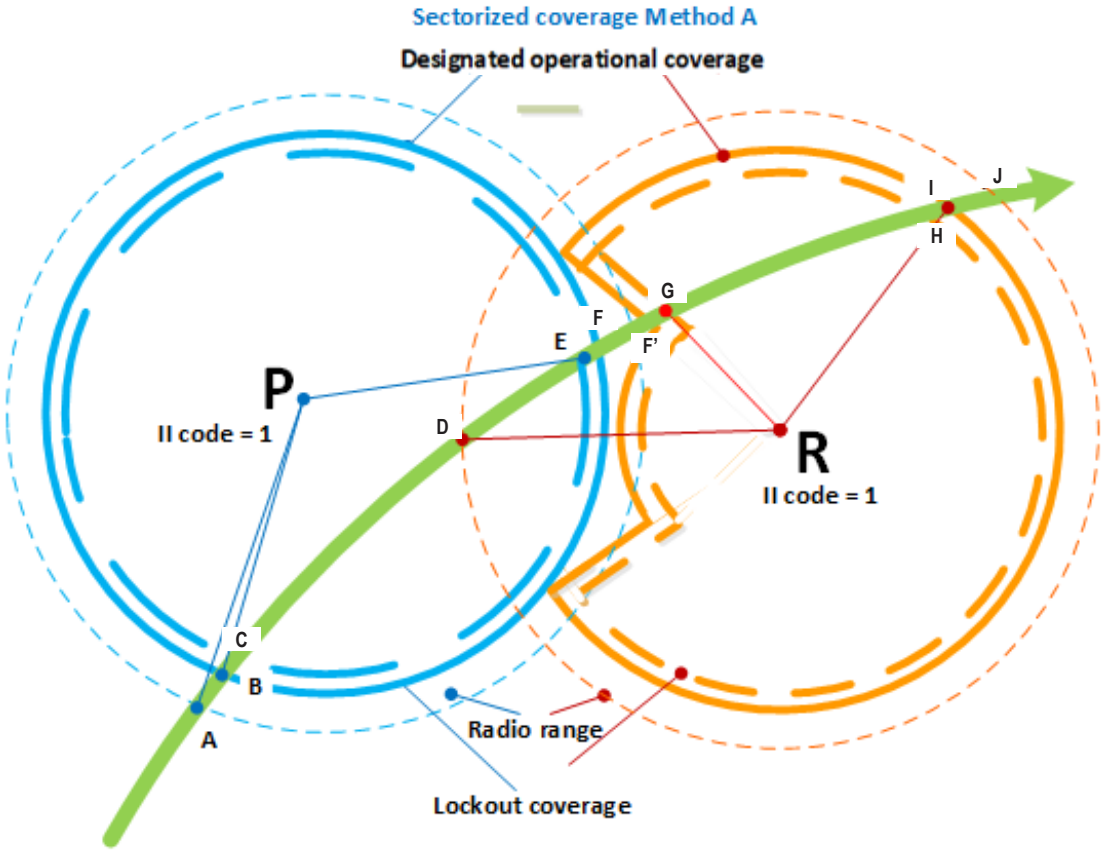


Figure J-30. Sectorized designated operational coverage (Method B)

8.5.4.2.3 In Figure J-30, an aircraft travelling from A to J will respond to interrogations of SSR Mode S ground stations (interrogators) P and R as follows (same approach as for Figure J-29):

a) When the aircraft is outside the surveillance coverage of the Mode S ground station P but is within the radio range (point A) where it can receive all-call interrogations from ground station P, the aircraft transponder replies to the all-call interrogations. The replies contain the IC of ground station P (II=01) and the 24-bit aircraft address. However, as long as the aircraft is outside the surveillance coverage of ground station P, the ground station does not accept the replies.

b) When the aircraft enters the surveillance coverage of ground station P (point B), the all-call replies from the aircraft transponder are accepted by ground station P. Then the aircraft is acquired and selectively interrogated by ground station P. The aircraft will be added to the list of “acquired aircraft” that is maintained by ground station P.

c) When the aircraft enters the lockout coverage of ground station P (point C), the ground station P sends selective interrogations commanding lockout to II=01 to the aircraft. Upon reception of these selective interrogation commanding lockout, the aircraft transponder will not respond to further all-call interrogations from ground station P and to all-call interrogations from other ground station s that have the same interrogator code (II=01 in this example).

d) When the aircraft is outside the surveillance coverage of the ground station R, but within the radio range (point D) where it can receive all-call interrogations on II=01 from ground station R, the aircraft transponder does not reply because it is locked on II=01 by ground station P.

e) When the aircraft leaves the lockout coverage of ground station P (point E), the ground station keeps on sending selective interrogation to the aircraft but without lockout request on II=01. After a period of 18 seconds the aircraft will lose its lockout status on II=01 and will reply to all-call interrogations received from ground stations P and R on II=01.

f) When the aircraft leaves the surveillance coverage of ground station P (point F), the ground station P stop sending selective interrogations to the aircraft. Contrary to the previous case where coverages are defined in a common grid specified in a global WGS-84 system of coordinates, the surveillance coverage of both ground stations may not be adjacent when coverage are reduced per sector (range reduced by sector). Therefore, there may be a gap between the surveillance coverages of ground stations.
When the aircraft enters the surveillance coverage of ground station R (point F’), the aircraft is unlocked on II=01. Therefore, the aircraft replies to all-call interrogations from ground station R on II=1, then it is acquired and selectively interrogated by ground station R.

g) When the aircraft enters the lockout coverage of ground station R (point G), the ground station sends selective interrogation commanding lockout to II=1 to the aircraft. Upon reception of these selective interrogations commanding lockout, the aircraft transponder will not respond to further all-call interrogations on II=1.

h) When the aircraft leaves the lockout coverage of ground station R (point H), the ground station keeps on sending selective interrogation to the aircraft but without lockout request on II=1. After a period of 18 seconds the aircraft will lose its lockout status and will reply to all-call interrogations on II=1.

i) When the aircraft leaves the surveillance coverage of ground station R (point I), the ground station R stop sending selective interrogations to the aircraft.

j) The aircraft will respond to all-call interrogations from ground station R as long as it is within the radio range of ground station R (until point J). These replies are not accepted by ground station R.

8.5.4.3 Lockout coverage reduction only

8.5.4.3.1 Adjacent Mode S ground stations have limited overlapping coverage areas and the same interrogator code is used for both ground stations, as already covered in the previous sections. In this example, only the lockout coverages of both ground stations are reduced in the overlapping region, the designated operational coverages (also referred to as surveillance coverage) are not reduced and are overlapping. The lockout coverages are reduced to create an internal buffer between coverages to ensure that the aircraft leaving the lockout coverage of the first ground station is unlocked while entering the surveillance coverage of the next ground station and can be acquired by the next ground station.

8.5.4.3.2 In Figure J-31, an aircraft travelling from A to K will respond to interrogations of SSR Mode S ground stations (interrogators) P and R as follows:

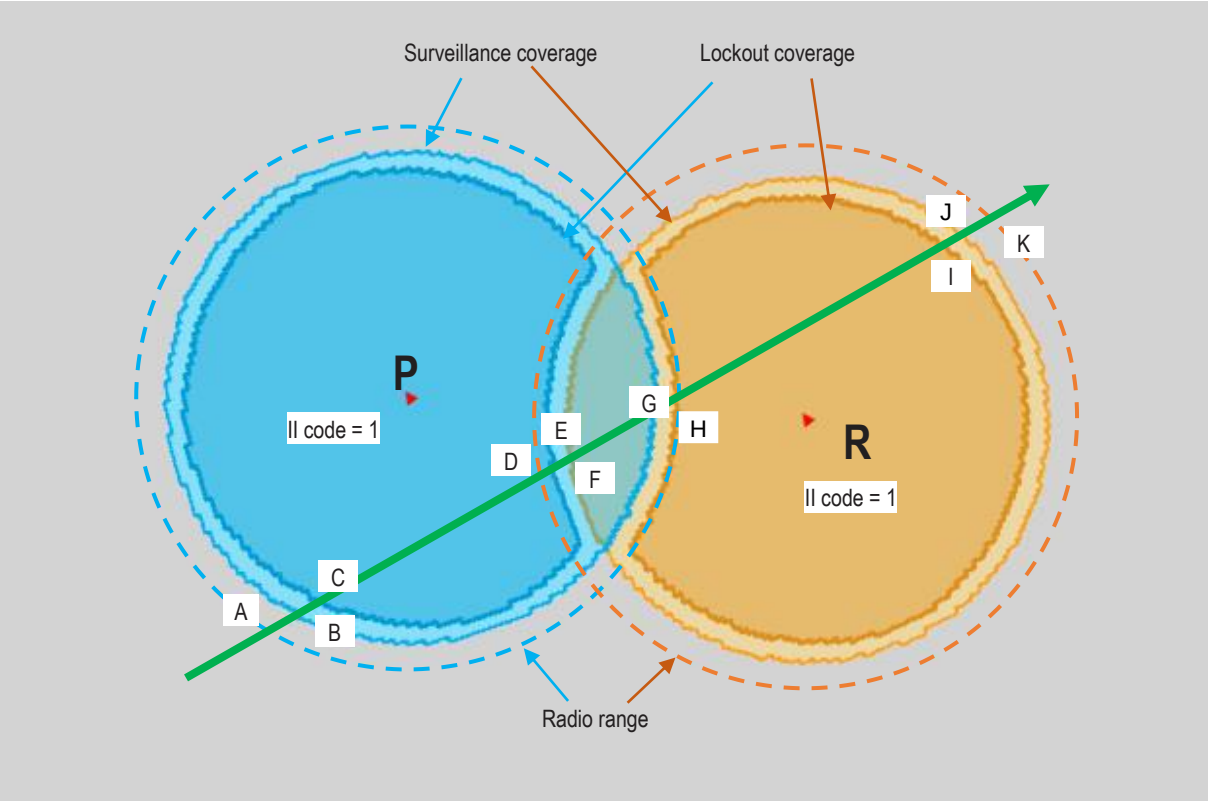


Figure J-31. Lockout coverage reduction

a) When the aircraft is outside the surveillance coverage of the Mode S ground station P but is within the radio range (point A) where it can receive all-call interrogations from ground station P, the aircraft transponder replies to the all-call interrogations. The replies contain the IC of ground station P and the 24-bit aircraft address. However, as long as the aircraft is outside the surveillance coverage of ground station P, the ground station does not accept the replies.

b) When the aircraft enters the surveillance coverage of ground station P (point B), the all-call replies from the aircraft transponder are accepted by ground station P. Then the aircraft is acquired and selectively interrogated by ground station P. The aircraft will be added to the list of “acquired aircraft” that is maintained by ground station P.

c) When the aircraft enters the lockout coverage of ground station P (point C), the ground station sends selective interrogations commanding lockout to II=1 to the aircraft. Upon reception of these selective interrogation commanding lockout, the aircraft transponder will not respond to further all-call interrogations on II=1.

d) When the aircraft is outside the surveillance coverage of ground station R, but within the (radio) range (point D) where it can receive all-call interrogations on II=1 from ground station R, the aircraft transponder does not reply because it is locked on II=1 by ground station P.

e) When the aircraft leaves the lockout coverage of ground station P (point E), the ground station keeps on sending selective interrogation to the aircraft as long as the aircraft is within the surveillance coverage of ground station P, but without lockout request on II=1. After a period of 18 seconds the aircraft will lose its lockout status on II=1 and will reply to all-call interrogations received from ground stations P and R on II=1.

f) When the aircraft enters the surveillance coverage of ground station R (point F) the aircraft is expected to be unlocked on II=1. Therefore, the aircraft is expected to reply to all-call interrogations from ground station R on II=1, then be acquired and selectively interrogated by ground station R.

g) When the aircraft leaves the surveillance coverage of ground station P (point G), the ground station P stop sending selective interrogations to the aircraft.

h) When the aircraft enters the lockout coverage of ground station R (point H), the ground station sends selective interrogation commanding lockout to II=1 to the aircraft. Upon reception of these selective interrogations commanding lockout, the aircraft transponder will not respond to further all-call interrogations on II=1.

That means that the aircraft is not locked on II 01 from point E where it leaves the lockout coverage of ground station P (after a period of 18 seconds) to point H where it enters in the lockout coverage of ground station R (i.e. outside the lockout coverage of ground stations P and R), and replies to all-call interrogations from ground stations P and R. In addition, the aircraft is selectively interrogated by ground stations P and R from point F to point G where the surveillance coverages of ground stations P and R are overlapping. This mode of operation should be used with care because it increases the number of all-call replies and therefore the RF pollution.

i) When the aircraft leaves the lockout coverage of ground station R (point I), the ground station keeps on sending selective interrogation to the aircraft but without lockout request on II=1. After a period of 18 seconds the aircraft will lose its lockout status and will reply to all-call interrogations on II=1.

j) When the aircraft leaves the surveillance coverage of ground station R (point J), the ground station R stop sending selective interrogations to the aircraft.

k) The aircraft will respond to all-call interrogations from ground station R as long as it is within the radio range of ground station R (until point K). These replies are not accepted by ground station R.

8.~~5.3~~5.5 Mode S ground stations with different interrogator ~~II~~ codes

8.~~5.3~~5.5.1 When SSR Mode S ground stations have different ~~II~~interrogator codes, no separation criteria between the Mode S ground stations needs to be applied. However, there is an exception in case a Mode S ground station which does not support the II/SI code operation is operating on II code, and another ground station is operating on an SI code matching the II code, as described in Section 8.2.6.

Origin SP/5	Considering the current growth of Mode S radar implementation and operation, the addition of guidance material on the assignment of SI codes and considerations to be taken into account when using SI codes is needed to facilitate the use of SI codes in all ICAO regions.