



# Radar Programming - MIP

Surveillance/MICA Workshop

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# Presentation content

- Definition of terms used to describe Mode S radar interrogation pattern
- Guidance material on how to configure Mode S radar interrogation pattern to reduce their contribution to 1030/1090MHz RF band usage

# Interrogations Definition

- Mode S Interrogator can use the following types of interrogations:

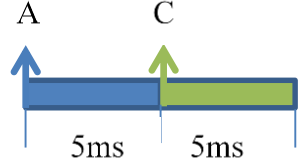
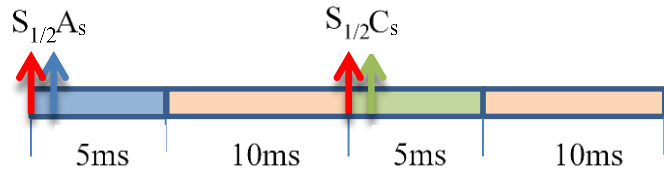
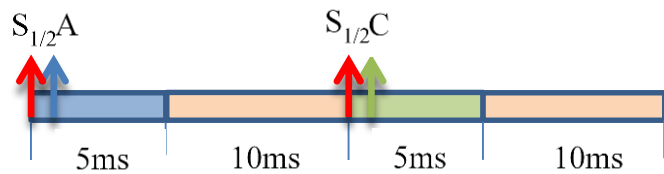
Acronym used in this document	Description	Pulse sequence
A	Mode A interrogation	P1 P3 at 8µs
C	Mode C interrogation	P1 P3 at 21 µs
A <sub>s</sub>	Mode A-only all-call interrogation	P1 P3 P4short
C <sub>s</sub>	Mode C-only all-call interrogation	P1 P3 P4short
S <sub>1/no</sub>	Mode S-only all-call interrogation with a probability of reply of 1/n. n could take the following values:1, 2, 4, 8 or 16. When PR=1, 1/n is not indicated.  "o" means lockout override used	P1P2P6 UF11
...	Mode S selective interrogations	P1P2P6 UF0/4/5/16/20/21

# Mode Interlace Pattern (MIP) Definition

- The mode interlace pattern (MIP) of an interrogator is the sequence of Interrogation periods that an interrogator is repeating.
- In Mode S, different periods during which different types of interrogation can be transmitted:
  - All-Call period (AC): interrogations broadcast to all aircraft in the beam.
    - contains 1 or 2 types of interrogation in general
    - E.g. Mode S-only all-call or Mode A/C-only all-call interrogations.
  - Roll Call period (RC): selective interrogations.
    - indicated by “...” in the description of a MIP

# MIP Example

- Mode AC radar MIP

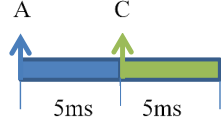
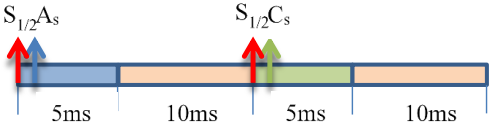
MIP	Description
A[5.0]/C[5.0]	
$S_{1/2}A_s[5.0]/\dots[10.0]/S_{1/2}C_s[5.0]/\dots[10.0]$	
$S_{1/2}A[5.0]/\dots[10.0]/S_{1/2}C[5.0]/\dots[10.0]$	

- Mode S Mix MIP:

- Mode A/C only all-call interrogations are replaced by Mode A/C interrogations (no P4).
- All aircrafts reply to Mode A/C interrogations, including Mode S aircrafts

# Interrogation Rate Frequency (IRF)

- The Interrogation Rate Frequency (IRF) is the number of interrogations of a specified type transmitted over a one-second period.

MIP	Description
A[5.0]/C[5.0]	
$S_{1/2}A_s[5.0]/\dots[10.0]/S_{1/2}C_s[5.0]/\dots[10.0]$	

- Example

	MIP	IRF
1	A[5.0] / C[5.0]	$IRF_A = 100 \text{ Hz}$ $IRF_C = 100 \text{ Hz}$ $IRF_{AC} = 200 \text{ Hz}$
2	$S_{1/2} A_s [5.0] / \dots [10.0] / S_{1/2} C_s [5.0] / \dots [10.0]$	$IRF_A = 38.5 \text{ Hz}$ $IRF_C = 38.5 \text{ Hz}$ $IRF_{AC} = 76.9 \text{ Hz}$ $IRF_S = 76.9 \text{ Hz}$

# ICAO requirements on IRF

- Mode AC radar:
  - Max 450 Mode AC per second ( $\text{IRF}_{\text{AC}} < 450 \text{ Hz}$ )
- Mode S radar:
  - Max 250 Mode S All-Call per second ( $\text{IRF}_{\text{S}} < 250 \text{ Hz}$ )
  - Max 250 Mode AC per second ( $\text{IRF}_{\text{AC}} < 250 \text{ Hz}$ )

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

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

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

*3.1.1.8.1.1 Recommendation.— To minimize unnecessary transponder triggering and the resulting high density of mutual interference, all interrogators should use the lowest practicable interrogator repetition frequency*

....

***3.1.2 Systems having Mode S capabilities***

***3.1.2.11.1.1 All-call interrogation repetition rate***

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

# ICAO requirements on All-Call interrogations

- Mode S radar shall trigger, in average, less than 6 All-Call replies in the beam per aircraft
  - Less than 26 All-Call replies over 18s
- ICAO Annex 10 Amendment 89

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

- In Europe, many radars are operating with 4 Mode All-Call replies in the beam



# Example

- Example: radar turning at 5s, 8 interrogation periods, LVA antenna

number of periods	8		8 All-Call interrogations with PR=1/2 → 4 All-Call replies in average in the beam
rotation period (s)	5		
range (NM)	200		
SLS beam (Deg)		4.8	
beam dwell time (ms)		66.7	= 5 (rotation period) / 360 * 4.8 (SLS beam)
Time between two successive periods (ms)		8.34	= 66.7 / 8
AC period (ms) 1/3 of time	0.33	2.78	
RC period (ms) 2/3 of time	0.67	5.56	
Range period All Call (NM)		225	= (3 x 10 <sup>8</sup> ) x (2.78 x 10 <sup>-3</sup> ) / 1852 / 2
IRF S or AC if combined (Hz)		120	= 1 / (8.34 x 10 <sup>-3</sup> )

# Guidance on Mode S All-Call

- Mixed Mode MIP (i.e. MIP including Mode A/C interrogations – no short P4) should not be used.
  - Rational: Mixed Mode MIPs may be used in area where too many transponders with deficiencies are operated.
- Mode S all call MIP should contain some interrogations with PR=1/2 or lower to facilitate the acquisition of aircraft in garbling situation and to reduce the number of triggered all call replies.
  - Rational: With PR=1 acquisition of aircraft entering at the same azimuth and range but at different altitudes could remain in garbling for a certain time.
- The Mode S radars with a fixed position should use permanent lockout.
- Lockout override should not be used by Mode S radar with a fixed position unless in fall-back mode of operation.

## Guidance on EHS parameter extraction (1/2)

- Interrogators should not extract registers that are not used by the system.
- Interrogators should not re-extract in the same beam or in the same second a transponder register after it has been received once unless a change has been reported through a specific mechanism (e.g. Comm B broadcast or change of bit in register  $10_{16}$ ).
- Interrogators should not attempt re-extracting the same parameter more than 2 times in a beam or in a second.
  - Rational: this is to avoid an interrogator re-extracting without success 10 times or more the same register.

## Guidance on EHS parameter extraction (2/2)

- Interrogators should not extract register  $10_{16}$ ,  $17_{16}$ ,  $1D_{16}$ ,  $20_{16}$  and  $30_{16}$  on repetitive manner. It should be extracted on track initialization or re-initialization or on change.
  - Rational: These registers are changing rarely and there is a specific protocol (Comm B broadcast) that indicates a change in register  $10_{16}$ ,  $20_{16}$  and  $30_{16}$ .
  - Note: as an **interim** transponder design deficiency workaround, these registers could be periodically re-extracted at a low rate (1 every minute or 10 scans) to overcome problems of bad Comm B broadcast protocol implementation on some transponders.