



# Operation on II and SI codes

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## Interrogator Code

- An Interrogator Code (IC) is either:
  - Interrogator Identifier code (II code), or
  - Surveillance Identifier code (SI code)
- 16 II codes are available: II code 0 to II code 15
  - 16 II codes was very limited
- 63 SI codes added in 1997: SI code 1 to SI code 63
- A discrete Interrogator Code is either an II code  $\neq 0$  or an SI code

## Mode S Protocols

- Interrogator Codes (IC) are used to support different Mode S protocols as defined in ICAO Annex 10 Volume IV:
  - the Mode S All-Call acquisition
  - the lockout protocol, and
  - the general purpose data-link protocols.

# Use of Interrogator Codes by Surveillance Systems

- Mode S radars
  - rely on All-Call interrogations and replies to acquire Mode S aircraft,
  - lock out acquired Mode S aircraft
  - general purpose data-link protocols (selective interrogations)
  - ➔ Mode S radars require IC allocation (except when operating on II code 0)
- ADS-B are passive systems and don't need an IC to operate
- Passive WAM systems don't need an IC to operate
- Active WAM systems don't use All-Call to acquire aircraft, don't lock-out aircraft, but use selective interrogations to interrogate aircraft
  - IC is required, II 0 is generally used
  - a discrete IC may be use by WAM systems if interrogations on 1030MHz need to be monitored

## II Code 0 and matching SI Codes

- Reserved by ICAO for Mode S interrogators that have not been assigned a unique discrete IC:
  - MLAT and WAM systems, and
  - Mobile Mode S interrogators for which it is not practical to allocate an IC
  - Operation on II 0 in accordance with the ICAO Standards and Recommended Practices
    - ICAO Annex 10 Vol IV Section § 3.1.2.5.2.1.4. and § 3.1.2.5.2.1.5.
    - Lockout override on II = 0 and Maximum All-Call interrogation rate
- II code 0 is not allocated by the MICA Cell
- SI codes matching II code 0 (SI 16, SI 32 and SI 48) are not allocated by the MICA Cell.

## II Code 14 and matching SI Codes

- II code 14 and SI codes matching II code 14 (SI 14, SI 30, SI 46 and SI 62) are allocated to Test, Research and Development (TRD) Mode S radar in the ICAO EUR region and the ICAO MID region

## II Code 15 and matching SI Codes

- II code 15 is reserved for NATO management in the ICAO EUR region .
- SI codes matching II code 15 (SI 15, SI 31, SI 47 and SI 63) are reserved for military operations in the ICAO EUR region.
  - Non-fixed deployable military radars
  - The management of these codes is the responsibility of NATO.
- II code 15 and matching SI codes (SI 15, SI 31, SI 47 and SI 63) are not available for allocation by the EUROCONTROL MICA Cell in the ICAO EUR region
- According to MID Region IC allocation process - June 2015 (approved by MIDANPIRG/15 – 12/06/2015)
  - ICAO MID regional office to decide how to use II code 15 and SI codes matching II code 15
  - To be discussed

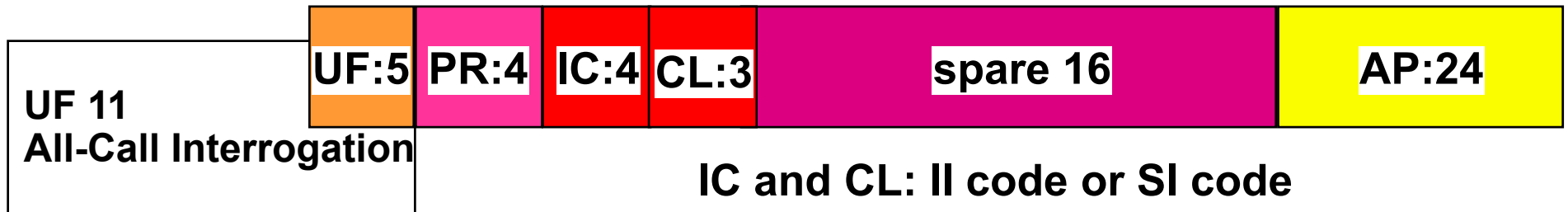
## IC allocated by the MICA Cell for operation

- List of IC available for allocation to operational Mode S interrogators by the MICA Cell:
  - II code 01 and matching SI codes (SI 01, SI 17, SI 33, SI 49)
  - II code 02 and matching SI codes (SI 02, SI 18, SI 34, SI 50)
  - II code 03 and matching SI codes (SI 03, SI 19, SI 35, SI 51)
  - II code 04 and matching SI codes (SI 04, SI 20, SI 36, SI 52)
  - II code 05 and matching SI codes (SI 05, SI 21, SI 37, SI 53)
  - II code 06 and matching SI codes (SI 06, SI 22, SI 38, SI 54)
  - II code 07 and matching SI codes (SI 07, SI 23, SI 39, SI 55)
  - II code 08 and matching SI codes (SI 08, SI 24, SI 40, SI 56)
  - II code 09 and matching SI codes (SI 09, SI 25, SI 41, SI 57)
  - II code 10 and matching SI codes (SI 10, SI 26, SI 42, SI 58)
  - II code 11 and matching SI codes (SI 11, SI 27, SI 43, SI 59)
  - II code 12 and matching SI codes (SI 12, SI 28, SI 44, SI 60)
  - II code 13 and matching SI codes (SI 13, SI 29, SI 45, SI 61)
- (Note: matching II codes and SI codes have the same IC field value – see below)



# Interrogator Code in All-Call Interrogations

## Mode S Only All-Call Interrogation (UF 11)



- IC field: 4 bits
- CL field: 3 bits
  - 000: the IC field contains the II code 0 to 15
  - 001: the IC field contains SI codes 1 to 15
  - 010: the IC field contains SI codes 16 to 31
  - 011: the IC field contains SI codes 32 to 47
  - 100: the IC field contains SI codes 48 to 63
- SI code capable transponder recognizes IC field and CL field (II and SI code)
- II code capable transponder recognizes only IC field (II code only)

## II capable and SI capable transponder

- SI code capability shall be provided [...] by all Mode S transponder by 1 January 2005 (ICAO Annex 10 Vol. IV § 2.1.5.1.7.1)
- Not all Mode S transponders are SI code capable
  - 99.9% of flights in Western Europe are reporting in the BDS 1,0 (Bit 35) that they are SI Code capable
  - **What is the status in the ICAO MID region?**
- II code capable transponders decode only the IC field
  - II code part of the IC contained in the All-Call interrogations
- Example: a radar operates on SI code 33 (IC=0001 and CL=011 in All-Call interrogations)
  - SI transponder will decode correctly the SI code 33
  - II transponder will decode II code 01 (II code matching SI code 33)

## Operation on SI code

- It is recommended for Mode S interrogators to support SI code capability
- SI code capable Mode S aircraft decodes correctly the SI code contained in the All Call interrogation (UF11) and replies with that SI code (DF11).
- II code capable Mode S aircraft decodes only the matching II code (IC field) in the All Call interrogation (UF11) and replies with that II code (DF11).
  - The All-Call reply on II code is discarded by the radar operating on SI code
- Mode S radars operating on SI code can acquire Mode S aircraft which are SI code capable, but cannot acquire aircraft which are II code capable.

## Operation on SI code with II/SI code operation

- It is recommended for Mode S interrogators to support II/SI code operation
- Mode S radars operating on SI code with II/SI code operation can acquire Mode S aircraft which are SI code capable and not SI code capable (II code capable)
  - accept All-Call replies on the SI code and on the matching II code
- These radars use the All Call replies to determine if a Mode S aircraft is SI code capable or not.
  - SI code capable Mode S aircraft decodes correctly the SI code contained in the All Call interrogation (UF11) and replies with that SI code (DF11).
  - II code capable Mode S aircraft decodes only the matching II code (IC field) in the All Call interrogation (UF11) and replies with that II code (DF11).
- Mode S transponders which are not SI code capable shall not be locked-out on the matching II code to enable the acquisition:
  - by other Mode S radars operating on SI code having the same matching II code
  - by other Mode S radars operating on the matching II code

## Operation on II code with II/SI code operation

- Mode S radars operating on II code with II/SI code operation use the SI code capability reported in Bit 35 of BDS 1,0 to determine if a Mode S aircraft is SI code capable or not.
- Mode S transponders reporting they are not SI code capable or not reporting their capability shall not be locked-out on the II code to enable Mode S radars operating on a matching SI code (with II/SI code operation) to acquire them on the II code if they are not SI code capable.

## Wrong SI code capability report (1/2)

- Some Mode S transponders may report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are not SI capable.
- If an II code and the matching SI codes are allocated to Mode S interrogators in the same region, Mode S transponders which report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are not SI capable:
  - will be locked on the II code by Mode S interrogators operating on II code
  - won't be detected (on the II code) by Mode S interrogators operating on the matching SI code (if already locked on the matching II code).

### **→ Loss of detection**

## Wrong SI code capability report (2/2)

- Some Mode S transponders may report they are not SI code capable (in Bit 35 of BDS 1,0) whereas they are SI capable.
- If an II code and the matching SI codes are allocated to Mode S interrogators in the same region, Mode S transponders which report they are not SI code capable (Bit 35 of BDS 1,0) whereas they are SI capable:
  - won't be locked on the II code by Mode S interrogators operating on II code
  - will be correctly detected and acquired on the SI code by Mode S interrogators operating on the matching SI codes.

**→ No problem of detection**

## II/SI Code Operation in the European Union

- To support the use of SI code in European Union, requirements on SI code and II/SI code operation have been lay down in Article 3 of COMMISSION REGULATION (EC) No 262/2009 of 30 March 2009
  - All Mode S radar shall support the use of SI code
  - All Mode S radar shall support the use of II/SI code operation



## II code and SI code allocation in ICAO EUR

- Allocation of II codes over matching SI codes is done in the ICAO EUR region.
- A study to identify Mode S transponders that report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are not SI capable has been done few years ago.
  - No faulty Mode S transponder identified during the test period.
- Monitoring means have been put in place (BDAMS tool):
  - Identification of Mode S transponders which are not SI capable
  - Identification of Mode S transponders that report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are not SI capable

## II code and SI code allocation in ICAO MID

- SI codes are allocated in the ICAO MID region
  - No regulation to support II/SI code operation in ICAO MID region
- II codes are not allocated in a region where the matching SI codes are allocated
- SI codes are not allocated in a region where the matching II code is allocated
- If more IC are needed in a region, the allocations on II code are withdrawn in order to be able to allocate the 4 matching SI codes
- A shortage of IC may happen in the future if both the II codes and the matching SI codes cannot be allocated in the same region.
  - % of Mode S transponders that are SI code capable
  - Monitor Mode S transponders that may report they are SI code capable (in Bit 35 of BDS 1,0) whereas they are not SI capable