Transmissions on 1030/1090MHz

Surveillance/MICA Workshop

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Usage of 1030/1090MHz

- The 1030/1090 MHz frequency bands are shared by several Surveillance Systems:
  - Military IFF (mode 1, 2, 4 and 5)
    - Fixed and mobile interrogators (on II = 00)
  - Mode A/C radars
  - Mode S radars
    - ELS and EHS
  - ACAS (Airborne Collision Avoidance System)
  - WAM (Wide Area Multilateration) / MLAT
    - Passive and active (interrogate aircrafts)
  - ADS-B
- The cohabitation of all these surveillance techniques :
  - increases the FRUIT and the number of collisions in the reception of interrogations and replies
  - reduces the performance of surveillance systems.

1030/1090 MHz Monitoring

- To maintain good performance on surveillance systems operating on 1030MHz (interrogations) and 1090MHz (replies), it is important:

    - to monitor and report the performance and the use of this RF band

    - to detect and investigate the unexpected transmissions on these frequencies

    - to study the interoperability impact between existing and new systems on this RF band.

Monitor Mode S Transponder Replies

- Monitor the 1030MHz and 1090MHz frequency bands to ensure aircraft are not over-interrogated

- Mode A/C → section 3.1.1.7.9.1 of ICAO Annex 10 Volume IV
  - At least 500 Mode A/C replies per second

- Mode S → section 3.1.2.10.3.7.3 of ICAO Annex 10 Volume IV, the minimum reply rate capability of Mode S transponder is provided:
  - 50 Mode S replies per second and 18 Mode S replies per 100msec
    - All-Call replies, Short Mode S replies to selective interrogations, TCAS replies
    - Acquisition squitters are not counted (DF 11 on II=0)
  - 16 long Mode S replies per second and 6 Mode S long replies per 100msec
    - Long Mode S replies (BDS extraction) to selective interrogations, TCAS replies
    - ADS-B Extended squitters are not counted (DF 17)

Need to Monitor Mode S Transponder Replies

- Event in 2014 showed that some transponder could stop working when subject to an interrogation rate greater to those defined in ICAO Annex 10 Volume IV and transponder MOPS.

  - important to verify that transponders are not subject to excessive rate of interrogations (below ICAO minimum reply rate capability).

ICAO Mode S minimum reply rate capability

Reply rate in Mode S – ICAO Annex 10 Volume IV

3.1.2.10.3.7 *Minimum reply rate capability, Modes A, C and S*

3.1.2.10.3.7.1 All reply rates specified in 3.1.2.10.3.7 shall be in addition to any squitter transmissions that the transponder is required to make.

3.1.2.10.3.7.2 *Minimum reply rate capability, Modes A and C.* The minimum reply rate capability for Modes A and C shall be in accordance with 3.1.1.7.9.

3.1.2.10.3.7.3 *Minimum reply rate capability, Mode S.* A transponder capable of transmitting only short Mode S replies shall be able to generate replies at the following rates:

50 Mode S replies in any 1-second interval
18 Mode S replies in a 100-millisecond interval
8 Mode S replies in a 25-millisecond interval
4 Mode S replies in a 1.6-millisecond interval

In addition to any downlink ELM transmissions, a level 2, 3 or 4 transponder shall be able to generate as long replies at least:

16 of 50 Mode S replies in any 1-second interval
6 of 18 Mode S replies in a 100-millisecond interval
4 of 8 Mode S replies in a 25-millisecond interval
2 of 4 Mode S replies in a 1.6-millisecond interval

In addition to downlink ELM transmissions, a level 5 transponder shall be able to generate as long replies at least:

24 of 50 Mode S replies in any 1-second interval
9 of 18 Mode S replies in a 100-millisecond interval
6 of 8 Mode S replies in a 25-millisecond interval
2 of 4 Mode S replies in a 1.6-millisecond interval

In addition, a transponder within an ACAS installation shall be able to generate as ACAS coordination replies at least 3 of 50 Mode S replies in any 1-second interval.

Monitor Transponder Occupancy

- When receiving an interrogation of sufficient power, the transponder processes it to verify if the interrogation elicits a reply or not.
    - If so, the transponder has to prepare the reply.

- During this time of processing, whether a reply is elicited or not, the transponder is unable to reply to other interrogations.
    - Too many interrogations may prevent the transponder to reply to some of them, and has an impact on surveillance systems.

Monitor Surveillance Systems Interrogations

- To ensure that ground-based interrogators are correctly configures
  - MIP
  - IRF
  - Number of All-Call interrogations and replies
    - No more than 6 All-Call replies, in average, in the beam
  - Lockout is applied
  - No Mixed Mode MIP
  - Number of BDS extracted every scan
  - …

Examples of problems

- Interrogations collision:
    - BDS swap happens when two interrogators send an interrogation to a same transponder, asking for two different BDS. If the interrogations reach the transponder at the same time, the transponder will only reply to one of them. One of the two radars will then receive a wrong reply. The more interrogators, the larger the number of BDS swaps.

- Transponder capacity limit:
    - Some transponders have implemented a limitation of their transmission when reaching the minimum capacity specified in ICAO Annex 10.