International Civil Aviation Organization

THE FOURTH MEETING OF MODE S DOWNLINKED AIRCRAFT PARAMETERS WORKING GROUP (MODE S DAPs WG/4)

Web-conference, 29 – 31 March 2021

Agenda Item 5: Review on the 1030/1090MHz occupancy in Asia Pacific

ICAO'S GUIDANCE ON MEASUREMENT OF 1030/1090 MHz USAGE

(Presented by Singapore)

SUMMARY

This working paper provides guidance material on the monitoring of the 1030and 1090 MHz frequency occupancy.

1. INTRODUCTION

1.1 During the SURICG/5, it was discussed that there is a need to ascertain the status of the 1030 and 1090 MHz frequency occupancy. In locations where the frequency occupancy is high, there may be a need for regular monitoring.

1.2 This paper aims to provide some guidance on the conduct of RF monitoring.

2. DISCUSSION

2.1 The Doc 9924 Aeronautical Surveillance Manual outlines some methods which can be used to perform measurement as well as the comparison of the various methods. **Annex A** provides an overview of the methods mentioned in the Doc 9924.

2.2 It is proposed that the text in **Annex A** be included in the Mode S DAPs Implementation and Operation Guidance Document.

3. ACKNOWLEDGEMENTS

3.1 The content of Annex A is extracted from ICAO Doc 9924 -Aeronautical Surveillance Manual.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) note the contents of this paper;

b) consider the inclusion of the material in **Annex A** into the Mode S DAPs Implementation and Operation Guidance Document; and

c) discuss and relevant matters as appropriate.

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Annex A

RF MONITORING

1.1 The 1030 and 1090 MHz frequency bands form the worldwide RF network, which enables the cooperative surveillance of mobile vehicles involved in ATM including airborne vehicles (aircraft) and ground vehicles (e.g. specific vehicles operating on airport surface in critical areas). It is utilized to support civil and military (IFF) air-ground surveillance applications, air-air surveillance applications and collision avoidance applications.

1.2 In general, the 1030/1090 MHz network is robust in its ability to support the systems that utilize it but as more systems are added, performance of one or more of these systems may degrade to unacceptable levels. Since many systems are safety critical in nature, protecting the 1030/1090 MHz spectrum from reaching unacceptable utilization is paramount.

1.3 Capacity of the system is impacted by the number and types of users. Aircraft density and the number and type of interrogators directly influence the activity on these links. Information extraction from ground and aircraft to aircraft interrogators increases the activity of these RF links. High density airspace is a particular challenge as these locations tend to contain accompanying higher density of ground interrogators. The systems that utilize the 1030/1090 MHz bands have standards that limit their impact to protect the performance of all users and provide robust capacity to the system. However, available capacity can be limited in the highest density areas of the world.

1.4 Therefore, it is necessary to monitor the usage of the 1030/1090 RF network, as is required for any telecommunication network, in order to regulate its use. Such monitoring should support the determination of the remaining margin of the network. It should help identify the sources of the utilization and whether the limits are being reached by misuse of some systems operating in a non-conforming or inefficient manner to the detriment of the good operation of the other systems using the same network.

<u>Airborne measurement vs ground measurement</u>

2.1 Airborne measurements provide a larger area of measurement but are more difficult to conduct and result in higher cost. The airborne measurements provide both the ability to characterize ground sensor operations (1030 MHz) and transponder occupancy. Providing a 1030 MHz measurement enables the detection of all types of interrogations to which a transponder is receiving, i.e. interrogations to which a transponder does or does not transmit a reply. Therefore, it allows an estimation of transponder occupancy at the given points of measurement. It also allows the tracking of interrogations received but not generating replies (e.g. SLS interrogations, interrogations directed to other aircraft).

2.2 Ground measurements are more easily accomplished, less expensive but geographically limited. They allow the verification of transponder transmissions on 1090 MHz but are limited in their ability of providing a complete understanding of the environment that airborne aircraft are experiencing. Estimates of 1030 MHz activity can be somewhat estimated from measurement of 1090 MHz replies. However, there is no way to completely account for interrogations that do not result in a reply that impact transponder occupancy.

<u>Methods in analysing frequency occupancy</u>

3.1 Method 1. This method calculates a simple time occupancy that corresponds to the amount of time that there is a signal present above a given threshold without trying to extract or even decode the content of the messages. The process can be based on the following criteria:

• 1090 MHz frequency occupancy is defined by the proportion of time that there is a signal above the MTL (-84 dBm) for pulses greater than 0.3 microseconds in duration; and
• 1030 MHz frequency occupancy is defined by the proportion of time that there is a signal above the MTL (-74 dBm) for pulses greater than 0.3 microseconds in duration.

3.2 Method 2. This method analyses the signal received on 1090 MHz, would be determined by decoding of, and counting the number of signals for different types of messages. The 1090 MHz frequency band occupancy can also be estimated using a predefined occupancy time for each type of message. This message occupancy time is defined as the time there is a signal transmitted on the frequency, i.e. a pulse is transmitted. It signifies how long the transmission is occupying the frequency and therefore possibly interfering with another signal.

Type of message	Time occupancy in µs
Mode A/C reply	4.05 (9*0.45)
Short Mode S reply or squitter	30 (60*0.5)
Long Mode S reply or Extended Squitter	58(116*0.5)

3.3 Method 3. This is similar to the previous methods. An alternate occupancy calculation is based on the number of signals received on 1 030 and 1 090 MHz, which are decoded and from which signal rates are determined. However, the occupancy considers the entire signal length from the leading edge of the first pulse until the trailing edge of the last pulse as the time duration regardless of whether and how many intermediate pulses are transmitted. The rationale behind this method is that in RF high-density areas, multiple signal garbling is likely to occur and therefore pulse gaps are unpredictably filled. The determination of the band occupancy is based on the signal durations.

Type of message	1030 MHz signal duration	1090 MHz signal duration
Mode 1	3.8 µs	20.75 µs
Mode 2	5.8 µs	20.75 µs
Mode 3/A	8.8 µs	20.75 µs
Mode C	21.8 µs	20.75 µs
Mode C (Whisper/Shout)	23.8 µs	20.75 µs
Mode A only All Call	10.8 µs	20.75 µs
Mode C only All-Call	23.8 µs	20.75 µs
Mode A/Mode S All-Call	11.6 µs	20.75 µs or 64 µs
Mode C/Mode S All-Call	24.6 µs	20.75 µs or 64 µs
Mode C only All-Call (W/S)	25.8 µs	20.75 µs
Mode A only All-Call (W/S)	12.8 µs	20.75 µs
Short Mode S	19.75 µs	64 µs
Long Mode S	33.75 µs	120 µs

Methods in analysing transponder occupancy

4.1 By analysing the transmissions made by a transponder, it is possible to verify if a transponder is transmitting above the minimum capabilities specified in Annex 10, Volume IV. The number of messages can be counted over 1 second and 100 msec sliding windows. The peak rates (i.e. the interval with the highest number of messages) detected over a given interval (e.g. 1 minute) can be compared to the values defined in Annex 10, Volume IV. Such information provides a good overall estimate of transponder activity caused by interrogators and makes possible the detection and further analysis of unexpected activity on the channel.

4.2 One method to estimate the number of messages transmitted by individual aircraft is by counting the number of messages received by a 1090 MHz receiver for aircraft in the vicinity of the receiver with a good link budget. However, achieving sufficient decoding performance is difficult but this method lends itself to a long-term ground-based monitoring system.

4.3 Another method is to conduct flight tests and detect and record the transmissions made by the operational transponder installed on the test aircraft. This is a good way to determine with high confidence the activity of an individual transponder in the environment. Decoding ownship replies is more accurate than attempting to analyse all the replies transmitted by all the other aircraft because the transmissions are received at high power, thereby reducing the problem of degarbling with other transmissions.

[The above material on RF monitoring is extracted and adapted from Doc 9924 Aeronautical Surveillance Manual]

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