

Interference and Compatibility Analysis of ARABSAT vis-à-vis EUTELSAT Systems and Networks

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Abstract—The paper presents an electromagnetic Interference and Compatibility Analysis for ARABSAT and Eutelsat Networks. The analysis suggests that ARABSAT has to accept certain constraints required to protect Eutelsat. An EIRP spectral density of -34 dBW/Hz in the direction of the Eutelsat space station is proposed in the uplink bands 14.0 - 14.5 GHz. In the downlink bands, an EIRP spectral density of -34 dBW/Hz towards the Earth. In addition, in the uplink band 13.75 - 14.0 GHz Eutelsat has imposed a constraint of -28 dBW/Hz. Although slightly over protective when using the larger bandwidth ARABSAT carriers, this limit is considered reasonable taking into account footnote 5.502, which limits EIRP in the 13.75 - 14.0 GHz band to between 68 and 85 dBW. The uplink constraint of -28 dBW/Hz offered by Eutelsat should be accepted. The results show that it will be possible for Arabsat to operate provided larger carrier bandwidths and antennas are used. The results demonstrate that for 27 and 36 MHz carriers, with antenna size of 3.5m, there is a positive C/I margin of around 4 dB. This is further improved with a 64 MHz carrier and 4.5m antenna size. In downlink direction Arabsat has priority for the majority of carriers and total priority in the band 12.2 - 12.5 GHz. However, where Eutelsat has priority (carriers 300KG9X and 35 M0G7W), analysis shows that EIRP of the 12.8 kHz ARABSAT carrier would need to be limited to 6.4 dB in order to meet the spectral density limit of -34 dBW/Hz. This is a reduction of 17 dB on the currently filed ARABSAT parameters. In the converse case, there are constraints on Eutelsat-3 required to protect Arabsat. In the uplink bands 14.0 - 14.5 GHz, an EIRP spectral density of -38 dBW/Hz in the direction of the ARABSAT space station. In the downlink bands, an EIRP spectral density of -28 dBW/Hz towards the Earth.

Index Terms— *Electromagnetic Interference and Compatibility, Satellite Communications, Frequency Coordination of satellite systems, Satellite Design constraints*

1 INTRODUCTION

In order to ensure successful operation, to avoid harmful interference, and to observe the procedures of the ITU Radio Regulations, a RF System, prior to its operation, has to carry out interference and compatibility analysis to seek a co-ordination agreement with a number of administrations, which have filing priority in respect of their Radio-communication Networks [12][13]. There is a very well bounded set of technical options available in trying to coordinate two satellite networks as described in ITU-R Rec.740 [12]. The fundamental approach to coordination is to calculate C/I or C/N+I ratios for all carrier pairs, and to compare these to coordination thresholds [1][2]. The difference between the two is often referred to as The Margin (M). So, if for all possible combinations of carriers:

$$M = C/I - \text{threshold} > 0$$

Then the situation is acceptable and the two systems can co-exist. If $M < 0$ some action is needed to improve the margin [12][13].

2 METHODOLOGY

In all analyses, rather than using the 12.2dB margin against the filed C/N, the satellites were compared using the accepted norm for a faster coordination, of a set C/I of 20dB, since it is

believed that EUTELSAT and their advisers will be amenable to this approach. In all cases, the Vis GSO coordination trigger matrix was used to identify the worst carrier combinations requiring protection [1][2][12]. The various analysis outputs were used to calculate the expected maximum EIRP power density in dBW/Hz which could be used and still provide a C/I of 20dB to EUTELSAT carriers in the Earth-to-space links. However, a check was made in order to ensure that where the $C/N + 12.2$ dB came too less than 20dB, the interfering system was not disadvantaged [8][10]. A similar exercise was completed for interference from ARABSAT into EUTELSAT in the downlinks. Similarly, an analysis was made of the interference which ARABSAT might expect from EUTELSAT in both the up and downlink bands, again against a 20dB C/I criteria to enable an assessment to be made of the types of services which might be provided [2][12]. This paper presents Electromagnetic Interference and Compatibility Analysis of the potential for coordination between the ARABSAT and Eutelsat satellite networks. The analysis is based on the satellite filings record available with ITU [1].

3 ANALYSIS

In all subsequent analysis, rather than using the 12.2 dB margin against the filed C/N, the satellites were compared using the accepted norm for a faster coordination, namely a set of C/I of 20 dB, since it is believed that Eutelsat and their advisers will be amenable to this approach. Results are presented in

terms of a C/I margin above or below this threshold. In the uplink direction, the results were used to calculate the maximum allowed EIRP spectral density (dBW/Hz) in the direction of the Eutelsat space station which could be used and still provide a C/I of 20 dB for Eutelsat carriers. Similarly, in the downlink direction the results were used to calculate the maximum allowed EIRP spectral density from the ARABSAT space station, and the results compared against the agreed coordination limits of -34 dBW/Hz [12][10]. Finally, a brief analysis was made of the interference which ARABSAT might expect from Eutelsat in both the up and downlink bands, again against a 20 dB C/I criteria, to enable an assessment to be made of the types of services which might be provided [12][10].

3.1. A note on the Interpretation of the Table below

The tables below show how interfering EIPR levels are constrained by agreed coordination limits and also by a 20dB threshold. The final two columns (Allowed Max EIRP, Max EIRP for Limit of XXdB) are to be compared. For interference from ARABSAT where the figure in the final column is the greater, then this is a favorable agreement. Where it is Allowed Max EIRP is greater, there is room to relax the coordination limit, as this implies that a ratio of 20 dB can be achieved with a larger coordination limit.

3.2. ARABSAT to EUTELSAT Uplinks

With the small orbital separation it must be expected that the potential for interference between the two satellites in the Earth-to-space direction is considerable. The objective of this analysis was to establish if there is any potential for use of the bands between 13.75 and 14.5 GHz on ARABSAT to provide service, without causing harmful interference to Eutelsat.

3.3 Summary of Uplink and Downlink Analysis

Table 1 Uplink Coordination Constraints

ARABSAT	Frequency	Eutelsat-3	Antenna	Achieved
Carrier	Band	Carrier	Size (m)	Margin
	(GHz)		(Arabsat)	(dB)
1M00G9X	13.75-14.0	68K3G1D	4.5 (TTC)	-3.16
1M00G9X	13.75-14.0	2M05G1D	4.5 (TTC)	2.27
1M00G9X	13.75-14.0	2M05G7W	4.5 (TTC)	3.17
6M40GXX	13.75-14.0	36M0F3F	4.5	4.60
27M0F3F	13.75-14.0	36M0F3F	4.5	12.93

Table 2 Uplink Coordination Constraints

ARABSAT	Frequency	Eutelsat-3	Antenna	Achieved
Carrier	Band	Carrier	Size (m)	Margin
	(GHz)		(Arabsat)	(dB)
12K8GXX	14.0-14.25	36M0F3F	1.2	-12.50
51K2GXX	14.0-14.25	36M0F3F	1.8	-11.98
410KGXX	14.0-14.25	36M0F3F	2.4	-11.84
12K8GXX	14.0-14.25	30M0F3F	1.8	-11.70
1M60GXX	14.0-14.25	36M0F3F	2.4	-11.43
12K8GXX	14.0-14.25	27M0F3F	2.4	-11.23

Table 3 Uplink Coordination Constraints

ARABSAT	Frequency	Eutelsat-3	Antenna	Achieved
Carrier	Band	Carrier	Size (m)	Margin
	(GHz)		(Arabsat)	(dB)
12K8GXX	14.25-14.5	36M0F3F	2.4	-12.50
51K2GXX	14.25-14.5	36M0F3F	1.8	-11.98
410KGXX	14.25-14.5	36M0F3F	2.4	-11.84
12K8GXX	14.25-14.5	30M0F3F	1.8	-11.71
1M60GXX	14.25-14.5	36M0F3F	2.4	-11.43
12K8GXX	14.25-14.5	27M0F3F	2.4	-11.25

3.4 Frequency band 13.75 - 14.0 GHz

In the 13.75 - 14.0 GHz band footnote 5.502 of the Radio Regulations applies [12][11]. At the time of filing, this limited Earth Station antenna sizes to a minimum of 4.5m, and EIRP emissions to between 68 dBW and 85 dBW. At WRC 2000 and 2003, this footnote was modified and now limits the Earth Station antenna size to a minimum of 1.2m and places restrictions on the power flux density at the coastline where antennas < 4.5m are used. The worst interference is caused by the 1 MHz ARABSAT TT&C carrier into the 68 kHz Eutelsat carrier (68K3G1D), where the C/I margin is -3 dB. Since this is a TT&C carrier we assume it will be coordinated on a case-by-case basis. It should also be noted that ARABSAT has priority over Eutelsat in this particular case. For other carrier combinations our analysis shows that the C/I requirement of 20 dB can be met with the currently filed ARABSAT parameters. The worst carrier combination (ignoring TT&C) gives a margin of at least 4 dB (ARABSAT carrier 6M40GXX to Eutelsat carrier 36M0F3F). This suggests that the agreed coordination limit of -28 dBW/Hz in this band is overly protective for Eutelsat carriers. In this example, the requirement to meet the -28 dBW/Hz limit would provide a C/I margin greater than 12 dB, and would require the ARABSAT transmit EIRP to be reduced by around 8 dB.

3.5 Frequency band 14.0 - 14.25 and 14.25 - 14.5 GHz

The proposed coordination agreement again appears to be based on a figure of -28 dBW/Hz for the bands 14.0-14.25 and 14.25-14.5 GHz. The figure below shows the frequency overlap where the highest levels of interference were recorded. Analysis based on the filed ARABSAT parameters shows

the worst margin is -12.5 dB, for the 12K8GXX / 36M0F3F carrier pair. To meet the C/I margin of 20 dB the ARABSAT EIRP spectral density in the direction of the Eutelsat space station would have to be reduced to around -34 dBW/Hz (equivalent to maximum transmit EIRP of 28.5 dB for a 1.2m antenna in the 14.0-14.25 GHz band). If Eutelsat were to impose an EIRP spectral density of -28 dBW/Hz (as for the 13.75-14.0 GHz band) then the maximum ARABSAT transmit EIRP would need to be reduced by around 6 dB from the currently filed values. A more likely limit is -34 dBW/Hz, which would require transmit EIRP to be reduced by around 12 dB from current values.

Table 4: Achievable margins in the 14.25 - 14.5 GHz band

ARABSAT	Frequ	Occupied	Eutelsat-3	Antenna	Achieved
Carrier	Band	Bandwidth	Carrier	Size (m)	Margin
	(GHz)	(MHz)		(Arabsat)	(dB)
27M0F3F	14.25-14.5	22.50	68K3G1D	3.5	3.39
36M0G7X	14.25-14.5	30.00	68K3G1D	3.5	4.61
64M0GXX	14.25-14.5	53.33	72M0G7E	4.5	15.81

4 ARABSAT TO EUTELSAT DOWNLINKS

A similar analysis was performed for a number of carrier combinations in the downlink bands 10.95-11.2, 11.45-11.7 and 12.2-12.75 GHz. In the majority of cases ARABSAT has priority in the coordination process. However, where Eutelsat has priority (indicated by the shaded entries in the table below) the interference is quite high, with the C/I margin exceeded by as much as 17 dB. Table 4 below provides a summary of the possible downlink coordination constraints.

Table 5: Summary of Downlink Coordination Constraints

ARABSAT	Frequ	Eutelsat-3	Achieved	Max EIRP
Carrier	Band	Carrier	Margin	Density Towards
	(GHz)		(dB)	Eut-3 (dBW/Hz)
12K8GXX	10.95-11.2	36M0F3F	-17.40	-34.91
12K8GXX	10.95-11.2	35M0G7W	-17.06	-33.97
12K8GXX	10.95-11.2	30M0F3F	-16.39	-33.30
51K2GXX	10.95-11.2	36M0F3F	-16.16	-34.00
410KGXX	10.95-11.2	36M0F3F	-16.13	-33.97
51K2GXX	10.95-11.2	35M0G7W	-16.04	-33.87
410KGXX	10.95-11.2	35M0G7W	-16.00	-33.84
12K8GXX	10.95-11.2	27M0F3F	-15.93	-32.85
12K8GXX	10.95-11.2	300KG9X	-13.83	-31.02

Table 6: Summary of Downlink Coordination Constraints

ARABSAT	Frequ	Eutelsat-3	Achieved	Max EIRP
Carrier	Band	Carrier	Margin	Density Towards
	(GHz)		(dB)	Eut-3 (dBW/Hz)
12K8GXX	11.45-11.7	36M0F3F	-17.20	-34.11
12K8GXX	11.45-11.7	35M0G7W	-17.08	-33.99
12K8GXX	11.45-11.7	30M0F3F	-16.41	-33.32
51K2GXX	11.45-11.7	36M0F3F	-16.18	-34.01
410KGXX	11.45-11.7	36M0F3F	-16.14	-33.98
51K2GXX	11.45-11.7	35M0G7W	-16.06	-33.89

Table 7: Summary of Downlink Coordination Constraints

ARABSAT	Frequ	Eutelsat-3	Achieved	Max EIRP
Carrier	Band	Carrier	Margin	Density Towards
	(GHz)		(dB)	Eut-3 (dBW/Hz)
12K8GXX	12.2-12.75	36M0F3F	-17.18	-34.10
12K8GXX	12.2-12.75	35M0G7W	-17.06	-33.97
12K8GXX	12.2-12.75	30M0F3F	-16.39	-33.30
51K2GXX	12.2-12.75	36M0F3F	-16.16	-34.00
410KGXX	12.2-12.75	36M0F3F	-16.13	-33.97
51K2GXX	12.2-12.75	35M0G7W	-16.04	-33.87

In the downlink bands, whilst priority is mixed, where interference occurs, ARABSAT has priority over Eutelsat for all carriers except 35M0G7W and 300KG9X. The figure below shows part of the 10.95-11.2 GHz band where the highest levels of interference were recorded. Ignoring the Eutelsat 36 MHz carrier (where ARABSAT has priority), the worst interference is caused by the 12.8 kHz ARABSAT carrier 12K8GXX into the 35 MHz Eutelsat carrier 35M0G7W, where the C/I margin is -17.06 dB. To meet the C/I margin of 20 dB the downlink EIRP spectral density from the ARABSAT space station would have to be limited to -34 dBW/Hz (equivalent to a maximum EIRP of 6.4 dB).

5 CONCLUSIONS AND RECOMMENDATIONS

The coordination limit of -28 dB/W/Hz towards Eutelsat 2 and 3 in the bands 14 - 14.5 GHz should be confirmed. A coordination limit on Eutelsat 3 in the band 12.2 - 12.5 GHz should be agreed at an EIRP spectral density of -28dB/W/Hz towards Earth.

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