THE GSMA **WRC SERIES**

Proposal on FSS protection criteria

March 2017

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1 Introduction

Some discussions on the protection criteria to be used in the sharing studies to be conducted under AI 1.13 and AI 1.14 are underway. These are important and the positions taken and consequent decisions made in various fora will impact on the outcomes of these studies. However, the specification of protection criteria is generally settled ahead of the sharing studies and so there is a limited amount of time available and most likely not enough time for significant supporting study work and associated detailed discussions to be completed.

In this paper, we set out a brief rationale for studies, in the period ahead, of the radio interference environment in space. In the meantime, we set out some proposals that aim to take us towards a more equitable apportionment of the interference margin available at satellite receivers, based on the existing scheme specified in ITU-R S.1432.

2 Existing criteria and a rationale for change

ITU-R S.1432 apportions aggregate interference from all sources incident to a FSS satellite receiver such that the degradation of noise ($\Delta T/T$) is 32% or 27% of the clear sky satellite system noise, dependent on frequency re-use. These criteria correspond to an interference margin of 1.2 dB or 1 dB.

The apportionments given in ITU-R S.1432 are as follows:

- 25% for all other FSS systems not practising frequency re-use
- 20% for all other FSS systems practising frequency re-use
- 6% for all other co-primary services
- 1% for all other sources

Clearly, the scheme is inequitable. Assuming an overall interference margin of 1 dB, interference from all *co-primary* sharers is limited by $\Delta T/T = 6\%$, corresponding to an interference margin of 0.25 dB and I/N = -12.2 dB, while other FSS systems may degrade noise by 20%, corresponding to an interference margin of 0.79 dB and I/N = -7 dB.

It is not clear whether the development of ITU-R S.1432 and the apportionment scheme in particular was supported by study work but these apportionments appear arbitrary and swung heavily in favour of the FSS. It seems appropriate, in modern times, with tremendous pressure on the spectrum resource, to question this scheme, progress towards a deeper understanding of the interference environment and the use of more equitable protection criteria in the sharing studies.

We understand, of course, that FSS networks are highly constrained but we are not clear as to whether the assumptions in ITU-R S.1432 are always in play with regard to FSS link planning, in particular the assumption of a 1 dB interference margin and a requirement that FSS networks require the lion's share of the interference margin at the expense of co-primary sharers.

GSMA has been considering possible engineering-based approaches to the refinement of protection criteria. These include the development of software models using realistic, or actual, deployment data to determine degradation of noise at FSS receivers in space due to aggregate interference sourced from co-primary sharers and other FSS networks. This type of approach could lead towards more precise models of the radio interference environment

Studies could also consider the use of C/I protection criteria in place of ΔT/T or I/N. Here, the strength of wanted and unwanted signals are considered. This could work well for some scenarios with progressive statistical modelling where we calculate variations in both wanted and unwanted signals incident to the victim receiver and consider the signal ratios required for normal operations including the fundamental carrier to noise plus aggregate interference ratio, C/(N+ΣI). However, while the use of C/I is part of the discussion, the proposals set out in this paper are in relation to ΔT/T and I/N values.

This is complex work and if we are serious about moving towards more realistic sharing studies, we have to accept that we are just at the beginning with many aspects to the problem requiring detailed investigation and study. However, we are faced with vital sharing studies *now* and the prospect of dated and conservative protection criteria being adopted. Therefore, we focus on just one aspect of the problem here and propose some alternative apportionment schemes for consideration.

3 Proposals

We set out some alternative apportionment schemes here that could be considered for use in the sharing studies in place of the existing ITU-R S.1432 apportionments.

Example 1

In this first example, we assume that interference margins of 1.2 dB or 1 dB are available at the FSS receiver in space, as per the existing scheme set out in ITU-R S.1432. In our revised scheme the 32% or 27% degradation of the clear sky satellite system noise (ΔT/T) is apportioned as follows:

- 21% for all other FSS systems not practising frequency re-use
- 16% for all other FSS systems practising frequency re-use
- 10% for all other co-primary services
- 1% for all other sources

Assuming an overall interference margin of 1.04 dB allowing for a 27% degradation of noise, these apportionments result in an interference margin for co-primary sharers of 0.41 dB and I/N = -10 dB while the interference margin for other FSS systems is 0.64 dB and I/N = -8.0 dB. The share of the interference margin available to other sources is unchanged.

If the overall interference margin is 1.21 dB allowing for a 32% degradation of noise, the interference margin for co-primary sharers is still 0.41 dB and I/N = -10 dB while the interference margin for other FSS systems is now 0.83 dB and I/N = -6.8 dB. There is no change to the margin available to other sources.

In this scheme we have moved towards a more equitable apportionment without any increase to the overall interference margins. This results in a larger apportionment for co-primary sharers while the FSS apportionment is reduced.

In the following examples, we assume that a larger overall interference margin is available, see [1] for example, and that frequency reuse is in play. We set out schemes that increase the ΔT/T values for both co-primary sharers and FSS.

Example 2

Here we assume an overall interference margin of 1.52 dB allowing for a 42% degradation of noise apportioned in the following way:

- 25% for all other FSS systems practising frequency re-use
- 16% for all other co-primary services
- 1% for all other sources

Here, interference from co-primary sharers is constrained by an interference margin of 0.64 dB and I/N = -8 dB. The interference margin for other FSS systems is 0.97 dB with I/N = -6 dB. The constraints on other sources remain unchanged.

This scheme requires a 0.48 dB increase to the overall interference margin (since 1.04 dB is required to support the ΔT/T = 27% specified in the current ITU-R S.1432 scheme). Relative to the existing scheme, other FSS networks are given an extra 5% ΔT/T and co-primary sharers an extra 10% ΔT/T. However, the apportionment scheme is still weighted in favour of FSS.

Example 3

In this example, we assume an overall interference margin of 1.79 dB with the 51% ΔT/T apportioned as follows:

- 25% for all other FSS systems practising frequency re-use
- 25% for all other co-primary services
- 1% for all other sources

Here, both co-primary sharers and other FSS systems are constrained by interference margins of 0.97 dB with I/N = -6 dB. The constraints on other sources remain unchanged.

This scheme requires a 0.75 dB increase to the overall interference margin (1.04 dB is required to support the ΔT/T = 27% specified in the current ITU-R S.1432 scheme). Relative to the existing scheme, other FSS networks are given an extra 5% ΔT/T and co-primary sharers an extra 19% ΔT/T. In this scheme, FSS and co-primary sharers are on an equal footing if there is only one other co-primary service in addition to FSS.

Illustrative noise-interference budget showing different ratios and margins

Figure 1 shows a simplified noise-interference budget illustrating the various signal levels and ratios at the victim receiver conceptually (the distance between signal levels do not reflect any particular scheme).

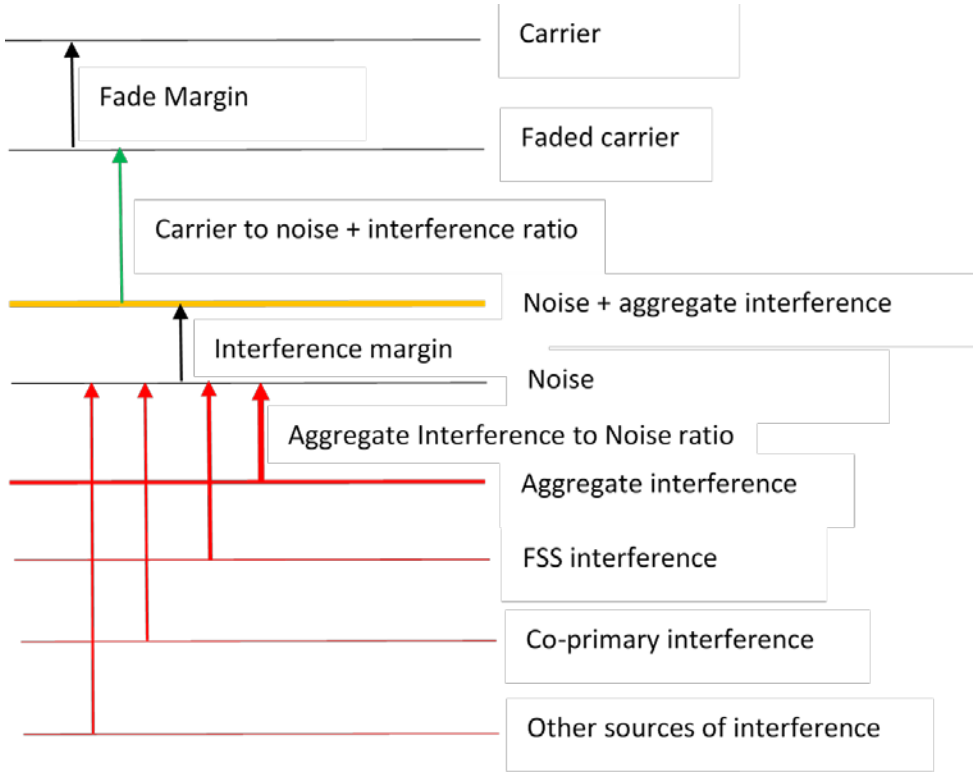

Figure 1 noise-interference budget

4 Conclusions

With unprecedented pressure on the radio spectrum and a real requirement to resolve complex sharing problems, it is no longer appropriate to engage in studies using dated and conservative protection criteria.

In this paper, we have set out a rationale for investigating the radio interference environment including software simulations using real or realistic deployment data. This could lead to radical changes to our understanding of these sharing problems.

In the meantime, we have set out some alternatives to the apportionment scheme set out in ITU-R S.1432. Each of these examples illustrate a more equitable approach to apportionment and spectrum sharing in general.

5 References

[1] Input to CPG CG on FSS protection criteria, Document 4A/FSSCRIT-E, “Protection Criteria of Systems in the Fixed Satellite Service”, 27 February 2017.