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Working Group 5

PROPOSED MODIFICATIONS TO THE DRAFT CPM REPORT

CHAPTER 5, AGENDA ITEM 9.1, ISSUE 9.1.2

AGENDA ITEM 9.1

9 to consider and approve the Report of the Director of the Radiocommunication Bureau, in accordance with Article 7 of the Convention:

9.1 on the activities of the Radiocommunication Sector since WRC-12;

NOTE: Eight issues have been identified by CPM15-1 under this agenda item.

5/9.1.2 Resolution 756 (WRC-12)

*Studies on possible reduction of the coordination arc and technical criteria used in application of No. **9.41** in respect of coordination under No. **9.7***

(**WP 4A** (technical and regulatory aspects), **SC** (regulatory and procedural aspects) / -)

5/9.1.2/1 Executive summary

The use of orbit spectrum resources is increasing and the difficulties in getting access to spectrum for new satellite networks is increasing accordingly. For these reasons, improved ways to accommodate new networks and facilitating more efficient use of the spectrum resources are sought while at the same time ensuring adequate protection of existing networks operating in accordance with the Radio Regulations (RR).

WRC-12 decided to reduce the coordination arc in the 6/4 GHz and 14/10/11/12 GHz frequency ranges, but also decided to further study the issue in accordance with Resolution **756 (WRC-12)**. It calls for studies regarding additional reductions in the coordination arcs in RR Appendix **5 (Rev.WRC-12)**, as well as to examine the effectiveness and appropriateness of the current criterion ($\Delta T/T > 6\%$) used in the application of RR No. **9.41** and consider any other possible alternatives, in order to facilitate coordination between FSS networks. Ultimately, WRC-15 agenda item 9.1, issue 9.1.2 is aiming to eliminate cases of "unnecessary coordination", limit the number of administrations/networks involved in the coordination process, and reduce administrative correspondence.

In response to Resolution **756 (WRC-12)**, options have been developed which include:

– reduction of the size of the coordination arc in selected frequency bands;

– replacement of the $\Delta T/T$ criterion used under RR No. **9.41** with a *C*/*I* criterion;

– replacement of the $\Delta T/T$ criterion used under RR No. **9.7** with a *C*/*I* criterion for frequency bands under item 9) of Table **5-1** of RR Appendix **5**;

– replacement of the *C*/*I* criterion used under RR No. **11.32A** with a pfd threshold in the 6/4 GHz and 14/10/11/12 GHz frequency ranges;

– increasing the level of permissible interference used in RR Nos. **9.41** and **11.32A** in selected frequency bands.

Various combinations of these options may be implemented and should be considered by WRC-15.

5/9.1.2/2 Background

The use of orbit spectrum resources is increasing and the difficulties in getting access to spectrum for new satellite networks is increasing accordingly. The situation is in particular severe in some frequency bands that are commonly used by many operational satellites, but there are also difficulties due to many submissions for satellite networks in other frequency bands.

The orbit spectrum resources are limited natural resources and, as such, they must be used rationally, efficiently and economically. For these reasons, improved ways to accommodate new satellite networks are sought while at the same time ensuring adequate protection of networks operating in accordance with the RR.

As part of the effort to improve the coordination process, WRC-12 decided to reduce the coordination arc in the 6/4 GHz, 14/10/11/12 GHz and 21.4-22 GHz frequency ranges. Furthermore, WRC-12 decided that these two issues would be further studied in preparation for WRC-15 and in its Resolution **756 (WRC-12)** *resolves to invite ITU-R*:

"1 to carry out studies to examine the effectiveness and appropriateness of the current criterion ($\Delta T/T > 6\%$) used in the application of No. **9.41** and consider any other possible alternatives (including the alternatives outlined in Annexes 1 and 2 to this Resolution), as appropriate, for the bands referred to in *recognizing e)*;

2 to study whether additional reductions in the coordination arcs in RR Appendix **5 (Rev.WRC-12)** are appropriate for the 6/4 GHz and 14/10/11/12 GHz frequency bands, and whether it is appropriate to reduce the coordination arc in the 30/20 GHz band,"

In addition to the studies specifically called for in *resolves to invite ITU-R* 1 and 2 of Resolution **756 (WRC-12)**, consideration should also be given to the need to keep the same criteria used in application of RR No. **9.41** and RR No. **9.7** for the frequency bands and services covered in item 9) of the frequency band column of Table 5-1 of RR Appendix **5** under provision RR No. **9.7**. Consideration should also be given to the impact of such an approach on RR Article **11** (e.g. RR No. **11.32A**)

5/9.1.2/3 Summary of technical and operational studies, including a list of relevant ITU-R Recommendations

The relevant ITU-R Recommendations: ITU-R S.465, ITU-R S.466, ITU-R S.483, ITU-R S.523, ITU-R S.524, ITU-R S.580, ITU-R S.728, ITU-R S.735, ITU-R S.739, ITU-R S.740, ITU-R S.741, ITU-R S.1323, ITU-R S.1432, ITU-R BO.1213.

The relevant Reports: PDN Report ITU-R S.[RES756], Report ITU-R S.2280, CCIR Report 455-5[31].

It is noted that the issues to be considered under *resolves to invite ITU-R* 1 and 2 of Resolution **756 (WRC-12)** are principally different and for this reason, they are addressed separately.

However, the goal of both *resolves to invite ITU-R* 1 and 2 are similar, i.e. to increase orbit use. In addition, it should be recognized that there is an interconnection between the issue of reducing the coordination arc and modifying the type and value of the coordination trigger, the level of interference, and therefore the implications of this interconnection should be carefully considered while deciding on these issues. Table 5/9.1.2/3-1 provides an overview of the current coordination triggers and protection criteria used in the RR for the cases studied.

[31] Note that CCIR (Consultative Committee on International Radio) is the predecessor to the ITU-R. CCIR became known as ITU-R in 1992.

TABLE 5/9.1.2/3-1

Current coordination triggers and protection criteria used in the RR for GSO networks subject to coordination under RR No. 9.7

<table>
<tr><th></th><th colspan="3">Identification of affected administrations by the Bureau</th><th>Self-identification under RR No. 9.41</th><th>Probability of harmful interference under RR No. 11.32A</th></tr>
<tr><td></td><td>Coordination Arc Approach
(Studies under resolves 2 of Resolution 756 (WRC-12))</td><td>Pfd approach</td><td>ΔT/T Approach</td><td>ΔT/T Approach
(Studies under resolves 1 of Resolution 756 (WRC-12))</td><td>C/I approach
(Studies under resolves 1 of Resolution 756 (WRC-12))</td></tr>
<tr><td>6/4 GHz band</td><td>±8°
FSS vs FSS</td><td rowspan="4">N/A</td><td rowspan="5">N/A</td><td rowspan="5">ΔT/T of 6%</td><td rowspan="8">C/I = C/N + 12.2 dB</td></tr>
<tr><td>14/10/11/12 GHz band</td><td>±7°
FSS or BSS vs FSS or BSS</td></tr>
<tr><td rowspan="4">30/20 GHz band</td><td>±8°
FSS vs FSS
As per items 3) & 7) under RR No. 9.7 in Table 5-1, Appendix 5</td></tr>
<tr><td>±8°
FSS vs BSS vs FSS
As per items 4) & 5) under RR No. 9.7 in Table 5-1, Appendix 5</td></tr>
<tr><td>±8°
FSS vs METSAT vs FSS
As per item 6) under RR No. 9.7 in
Table 5-1, Appendix 5</td></tr>
<tr><td>±16°
FSS or BSS vs FSS or BSS
As per item 8) under RR No. 9.7 in
Table 5-1, Appendix 5</td><td>N/A</td></tr>
<tr><td>21.4-22 GHz band</td><td>±12°
BSS vs BSS
As per item 6bis) under RR No. 9.7 in Table 5-1, Appendix 5</td><td>Pfd mask
(Resolution 554 (WRC-12))</td><td></td><td rowspan="3">N/A</td></tr>
<tr><td>21.4-22 GHz band</td><td>±9°
BSS vs BSS
(see Resolution 553 (WRC-12))</td><td>Pfd mask
(Resolution 553 (WRC-12))</td><td></td></tr>
<tr><td>Other bands (see item 9) of Table 5-1 of RR Appendix 5)</td><td>N/A</td><td>N/A</td><td>ΔT/T of 6%</td></tr>
</table>

Some effects of the above mechanisms to be noted are:

1) Unnecessary coordination may be required inside the arc when there is no probability of harmful interference (e.g. non-overlapping coverages).

2) Networks at great orbital separations can request to be included in the coordination process even though these networks will have had to accept much higher interference levels from more nearby networks.

3) Special sensitive characteristics (possibly unrealistic parameters) for submissions may cause additional coordination requirements for later submissions for far away networks and hinder coordination of these.

4) Unnecessary coordination requirements together with the requirement to submit the notification within 7 years after submission of the API, in particular when real satellite projects are involved, force administrations to use RR No. **11.41** in order to be able to initiate the notification process within the seven-year regulatory period.

In preparation for WRC-12, proposals were made wherein coordination requirements outside the coordination arc were based upon more precise assessment of the interference into a network. The criterion used to trigger coordination could be either in the form of a pfd criterion or a *C*/*I* criterion.

WRC-12 decided that these mechanisms should be further studied as potential replacement to the technical criterion ($\Delta T/T$ of 6%) used in the application of RR No. **9.41** (see Annexes 1 and 2 to Resolution **756 (WRC-12)**).

5/9.1.2/3.1 Technical and operational studies in respect of *resolves* 1

5/9.1.2/3.1.1 What interfering levels should be considered for coordination triggers/protection criteria

The objective is to discuss what could constitute appropriate interference levels used as coordination triggers and protection criteria and what would be the impact for practical satellite networks in the 6/4 GHz and 14/10/11/12 GHz frequency ranges (see PDN Report ITU-R S.[RES756]).

All current relevant ITU-R Recommendations, regardless of $\Delta T/T$, I/N, $I/(N+I)$ or C/I criterion being used, are based on one and the same interference level, equivalent to 6% of thermal noise increase for single entry interference and 20%-25% for aggregate interference from geostationary-satellite orbit (GSO) FSS networks. These values were adopted many years ago with satellites with very low power, earth station front-end receivers with very high noise temperature, using a small number of large earth station antennas and a small number of operating FSS and BSS networks with wide orbital separation. Under such conditions, link design was determined by C/N requirements. Allowable interference, which, due to the few satellites and large earth station antennas, at that time in practice was low, was set as a marginal degradation of the C/N.

Currently, the power resources of satellites have increased considerably. At the same time, earth station front-end receiver noise temperature is seen to have been reduced significantly. These factors have allowed use of large numbers of small earth station antennas. Moreover, the number of satellites and the spectrum occupation by communication satellites operating in the 6/4 and 10/11/12/14 GHz frequency ranges has drastically increased. As a result, link designs today are much more limited by adjacent satellite interference than before, in some cases to the extent that C/I becomes comparable to C/N. Furthermore, the transition from analogue to digital modulation has significantly changed the interference potential and the protection requirements for satellite networks.

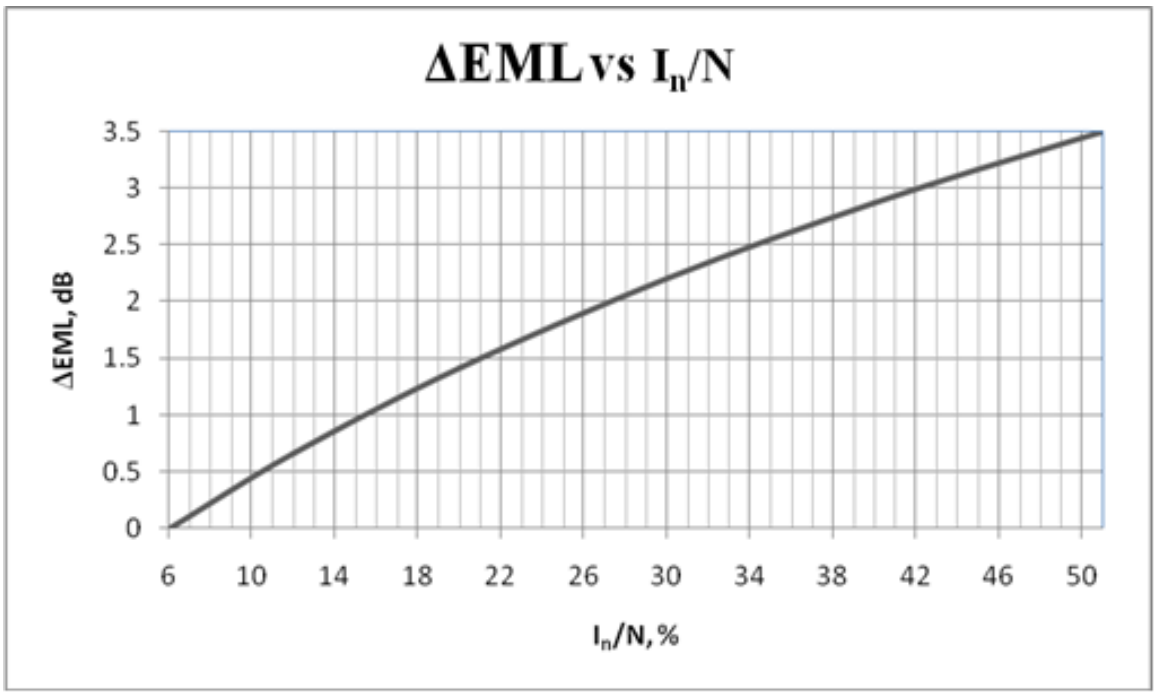
There is an obvious difference between interference levels for triggering coordination, and levels of interference to be accepted in practical coordination. Nevertheless, in a situation with a large number of satellite networks sharing the orbit spectrum resources, significantly higher levels of interference are seen to be accepted in practical coordination; both by the incumbent and the incoming networks.

A study[32] was performed in order to assess the appropriateness of the current 6% $\Delta T/T$ criterion in an operational environment consisting of practical co-frequency, co-coverage and co-polarized satellites typically spaced about 2 to 3 degrees apart along the GSO arc in the C and Ku bands. This study demonstrates that in such an operational environment, the calculated interference level from adjacent satellite networks will correspond to an increase of the system noise temperature by much more than 6%. In fact the study shows that the calculated interference will indeed correspond to a minimum increase of the $\Delta T/T$ in the order of 20% in C band and 40% in Ku band.

Studies[33] have also shown that increasing $\Delta T/T$ from the current 6% to 12, 20 and 50% allows the angular separation between adjacent FSS satellites to be decreased by a factor of 1.3, 1.6 and 2.3 respectively. This makes it possible to accommodate additional FSS networks in the GSO and to facilitate coordination of new networks.

A consequence of increasing the interference level is that each network would lose energy margin equal to 0.66, 1.42 and 3.45 dB respectively (for links with initial ratio $C/(N+I)$ = 10.5 dB, see Figure 5/9.1.2/3-1) or capacity of each network would decrease by 5.5%, 12% and 28% respectively. Using modern engineering techniques, energy margin losses up to 1.5-2 dB may be compensated for most of networks without capacity losses.

FIGURE 5/9.1.2/3-1



[32] See PDN Report ITU-R S.[RES756].

[33] See PDN Report ITU-R S.[RES756].

Another study[34] was conducted to gain an understanding of the relationship between the current single-entry and aggregate interference criteria for the case of homogeneous occupancy of the GSO with equal power satellites spaced uniformly every 2-3° and the aggregate interference from neighbouring satellites limited to 20 or 25% $\Delta T/T$. The results of this study suggest that, under the given assumptions, the ratio between single-entry and aggregate interference could be increased by a factor of about 1.6. However, it was recognized that practical cases can differ from the assumed case.

In preparation for WRC-12, prospective pfd downlink masks and uplink levels to be used in respect of protection of unplanned FSS in the 4/6 and 10/11/12/14 GHz ranges were studied. The pfd masks/levels were generated to provide a protection equivalent to that afforded by a $\Delta T/T$ of 6% to a range of key technical parameters. By doing so, protection is afforded to a specified level of interference, determined from a defined range of key parameters, which is independent of specific parameters of individual submissions. As a result, combinations of parameters in submissions which today would be more sensitive to interference from new networks would no longer retain such protection.

For other levels of permissible interference, the pfd masks/levels would need to be adjusted accordingly by a factor 10log(X%/6%) dB. In considering replacement of some of the current protection criteria by pfd masks/levels, consideration also needs to be given as to if these should be in the form of hard or soft limits.

5/9.1.2/3.1.2 The nature of different types of coordination triggers/protection criteria

In addition to the coordination arc, mainly three different types of coordination triggers or protection criteria are used in the RR; $\Delta T/T$, *C*/*I* and pfd. Table 5/9.1.2/3-1 provides examples of the current application of these criteria in the RR.

$\Delta T/T$

This is the traditional coordination trigger used for the unplanned frequency bands. Although used to trigger coordination, $\Delta T/T$ considerations are not commonly used in practical frequency coordination. This criterion has the same value for links with different carrier-to-noise ratios and different parameters, such as antenna size, pfd, etc. and does not contain any assessment of whether or not the parameters or the combinations of these represent realistic link designs. Furthermore, the $\Delta T/T$ method does not encourage use of homogeneous parameters to foster efficient spectrum usage and facilitating access for new satellite networks.

C/*I*

C/*I*, or variants of *C*/*I*, are used in the frequency bands contained in RR Appendices **30**, **30A** and **30B** as well as in the Bureau's examination under RR No. **11.32A**. *C*/*I* or *C*/*(N+I)* are also commonly used in practical frequency coordination between satellite networks. Depending on its implementation, *C*/*I* criteria may or may not encourage use of homogeneous parameters. If *C*/*I* criteria are used without any limitations on the technical parameters, either allowed in a filing or used in conducting the *C*/*I* analyses, the *C*/*I* criteria, just like $\Delta T/T$, will provide no encouragement to use homogeneous parameters and can also lead to artificially high protection of some links.

If such limits are included, these will limit such adverse effects. Introducing a limit on the range of technical parameters that are allowed to be contained in a filing is something that is currently not used for satellite networks in the RR and may be seen as refusing administrations to submit filings describing the parameters of their planned satellite networks. Moreover, *C*/*I* criteria might have

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[34] See PDN Report ITU-R S.[RES756].

difficulties capturing submissions for satellite networks that can operate within a regular interference environment, but with very different technical characteristics (e.g. spread spectrum networks).

C/*I* or Δ*T*/*T* criteria will give similar permissible interference value irrespective of *C*/*N* ratio value. However, in case of partial overlap of the interfering and the wanted signal frequency bandwidths, since it takes into account the actual frequency and bandwidth of the wanted and the interfering signals as well as an apportionment of excess margin[35] to the adjacent satellite interference[36], the number of affected satellite networks will be reduced when using the *C*/*I* approach compared to the results obtained using the Δ*T*/*T* approach (see Recommendation ITU-R S.741, Rules of Procedure (RoP), Section B3).

Application of *C*/*I* together with a limitation on the range of technical parameters allowed in submissions or used in the examination by the Bureau would facilitate the:

– elimination of cases of "unnecessary coordination";

– reduction of the networks/administrations involved in the coordination process;

– reduction of administrative correspondence.

Use of the *C*/*I* criterion at application of the provisions of RR Articles **9** and **11** would lead to uniformity at these two stages of filing examination:

– justifying the inclusion of additional affected administration/network outside the coordination arc in case of application RR No. **9.41**;

– in the coordination process; and

– in application RR No. **11.32A**.

Pfd masks/levels

To provide a criteria that is easy to apply and at the same time provides an adequate protection for a representative range of technical parameters, i.e. encouraging use of homogeneous parameter which facilitate efficient use of orbit spectrum resources, pfd downlink masks and uplink levels were introduced by WRC-2000 when revising RR Appendices **30** and **30A** and by WRC-12 when revising the coordination procedures for the 21.4-22 GHz unplanned BSS frequency band.

Pfd masks and levels define an interference environment that satellite networks need to adapt to and wherein satellite networks can be introduced in a flexible manner without the need for strict limits on particular technical parameters.

Compliance with the pfd mask will permit the administration submitting the new network to get a favourable BR finding without coordination with another network if it will be shown that the new network pfd generated throughout service area of the other network is lower than pfd mask limits for the given angular separation between considered geostationary (GSO) networks. The pfd masks and levels are determined based upon a range of key technical parameters. Networks with parameters which would lead to higher interference sensitivity using the current criteria which are based upon the parameters contained in the submissions for individual satellite networks will not enjoy a higher degree of protection against interference than other networks. On the other hand, networks with parameters resulting in lower sensitivity to interference than that resulting from the

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[35] The margin between the minimum *C/(N+I)* calculated from RR Appendix **4** data and the *C/N* objective (RR Appendix **4**, Annex 2, item C.8.e.1) should be a positive value (equal to or more than 0 dB). In this document, this margin is referred to as the "excess margin".

[36] See PDN Report ITU-R S.[RES756].

range used to determine the pfd mask will be more protected using the pfd mask than using the current criteria. It should also be noted that application of the pfd mask-based method does not exclude specific calculations in respect to the affected networks during the coordination process.

Introducing the pfd mask method would encourage administrations to ensure that the sensitivity to interference of networks, requested for coordination, should not exceed the sensitivity of the reference network to avoid interference from networks submitted later which will also be examined under the pfd mask method. The pfd mask method thus facilitates gradual standardization of FSS network parameters with regard to its interference sensitivity, i.e. homogeneity of these networks. In certain cases, application of the pfd mask method may also make it possible to avoid the coordination with satellite networks which are located inside the coordination arc, but where the mask is satisfied due to sufficient separation between networks service areas.

The maximum uplink pfd produced at the GSO at the location of the interfered with satellite is derived from:

– interference threshold level (e.g. equivalent to a given $\Delta T/T$ value);

– the range of the G/T of the receiving space station.

The maximum value within the range of reasonable G/T values to be taken into account will determine the uplink pfd level. For satellite networks with national coverage, higher levels of protection from uplinks towards other satellites can be provided by that administration as a part of their national legislation through the licensing of uplink earth stations by requiring lower off-axis e.i.r.p.s towards that satellite network from earth stations located in that country.

Similarly, the downlink pfd mask is the value of permissible pfd at the Earth's surface, depending on the angular separation between satellites of two networks. The pfd values are derived from:

– interference threshold level (e.g. equivalent to a given $\Delta T/T$ value);

– the system noise temperature of the receiving earth station;

– the range of antenna sizes to be taken into account;

– the off-axis reference antenna diagram.

A study submitted to ITU-R (see Document CPM15-2/50(Rev.1)) presented analyses of pfd masks based upon an interference level corresponding to the equivalent of $\Delta T/T$ = 20% which showed that:

− any network in the 10/11/12 GHz band, meeting RR Article **21** requirements to the pfd limits (−150/−140 dB(W/m^2 4 kHz)), would meet proposed pfd mask with angular separation at the GSO more than 4.5°/8.6° and would get favourable BR finding under RR No. **11.32A** independently of affected networks involved in coordination under RR No. **9.41**;

− any network in the 4 GHz band, meeting RR Article **21** requirements to the pfd limits (−152/−142 dB(W/m^2 4 kHz)), would also get favourable BR finding under RR No. **11.32A** using proposed pfd mask with angular separation at the GSO more than 7.8°/19.6°.

It should be borne in mind that the pfd criterion is considered for introduction in congested frequency bands where satellites already today are operating co-frequency, co-coverage, co-polarized with 2-3° orbital separation and where practical satellites out of necessity have been required to adapt to a certain interference environment. If different applications and satellite networks have very different characteristics, efficient spectrum usage is infeasible. If the pfd values aim at encompassing the entire range in such cases, including even the submissions for the most sensitive satellite networks, they could become overprotective, not serving the purpose of facilitating access for new satellite networks.

5/9.1.2/3.1.3 Representative range of technical parameters

It is seen that submissions for satellite networks often contain a wide range of technical parameters. Some of the combinations of these parameters may lead to unrealistic links that are either very sensitive to interference (i.e. trigger coordination very easily) or create unrealistic high levels of interference.

The latter case is addressed by requiring coordination when exceeding certain limits. Since protection is based upon single-entry criteria, this has no implications in respect of later submissions.

However, very sensitive links will not require any additional coordination, yet they have the capability of requiring unreasonable coordination from later incoming submissions, thus unreasonably blocking access to orbit spectrum resources for newcomers[37]. To avoid this, the coordination requirements of new submissions would need to be determined on what is deemed a reasonable range of technical parameters, either through defining pfd masks based upon a standardized range of parameters or through *C/I* assessments using a standardized range of parameters. But the use of homogeneous (with standard range of parameters) networks will limit design flexibility and creation of non-standard networks by administrations.

An important part of this is that a reasonable range of technical parameters shall be given an adequate protection. However, and this is also a part of the aim, some submissions may still contain link combinations outside this range, but these should not lead to unreasonable levels of protection and hindrance of coordination of new satellite networks.

On the other hand, existing (and brought into use) networks with technical parameters outside "a reasonable range of technical parameters", which may occur to be more sensitive to interference, shall also have a right for protection. This may require to create a special set of technical parameters for such networks.

For the development of pfd masks and levels, it is seen that in particular uplink G/T and downlink system noise temperature, range of antenna sizes and off-axis antenna pattern are the important technical parameters to define (see PDN Report ITU-R S.[RES756]).

5/9.1.2/3.1.4 Use of provision RR No. 9.41

Statistics on the use of RR No. 9.41

Statistics of ITU-R[38] have observed a steady increase of the use of RR No. **9.41** and show that after WRC-12 reduced the coordination arc in the 6/4 and 14/10/11/12 GHz frequency ranges and made the list of networks under RR No. **9.36.2** definitive, the average number of networks requested for inclusion under RR No. **9.41** per CR/C had increased from 21 to 34. Furthermore, while previously about 1/5 of the submissions did not receive comments in respect of RR No. **9.41**, after the changes by WRC-12 practically all networks now receive such comments. It is important to note that in practice, the number of satellite networks that are used by administrations to self-identify under RR No. **9.41** is less than the number of satellite networks eligible to this provision. Furthermore, the

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[37] A study by the Bureau (see PDN Report ITU-R S.[RES756]) showed that because of too wide range of characteristics of assignments submitted by administrations and recorded in the MIFR, the identification of the affected administration and networks, even using *C/I* criterion, leads to extreme coordination requirements with the identified networks located at very large orbital separation. These studies also showed that without addressing the range of representative technical parameters, a change from $\Delta T/T$ to *C/I* would not significantly reduce the coordination requirements.

[38] See PDN Report ITU-R S.[RES756] for further statistics.

satellite network for which a request under RR No. **9.41** is submitted to the Bureau may sometimes already have been identified by the Bureau.

Implications on the use of RR No. 9.41 by changes to the criteria and the value

A study conducted by the Bureau on submissions already filed[39] showed that simply changing from $\Delta T/T$ to C/I criterion alone would have no impact in respect of very sensitive carriers / "unrealistic links" used in submissions and would not significantly reduce coordination requirements unless the issue of developing a representative range of technical parameters is considered as well.

Two studies[40] have shown that an increase in the value of the technical criterion used in application of RR No. **9.41** could reduce the number of potentially affected networks outside the coordination arc (i.e. networks which may be included into the list of affected networks under RR No. **9.41**). Increasing the value of the technical criterion used in the application of RR No. **9.41** might also increase the number of networks inside the coordinated arc subject to possible exclusion from the list by a notifying administration, and thereby would reduce the total number of affected networks.

The issues identified above should also be considered when determining the value of the coordination arc in frequency bands allocated to the FSS.

5/9.1.2/3.1.5 Impact on the workload of the Bureau

Since the decisions of WRC-12, where the list of identified affected networks under RR No. **9.36.2** became definitive and the coordination arc was reduced in the 6/4 GHz and 14/10/11/12 GHz frequency ranges, the Bureau, as shown in the previous section, has been observing a steady increase in the number of requests submitted under RR No. **9.41** per coordination request (CR/C).

The percentage of the CR/Cs for which RR No. **9.41** comments are received has increased from 80% for the CR/Cs received between 1.09.2010 and 1.01.2013 to almost 100% for CR/Cs received after 1.01.2013.

The Bureau has not received so far any RR No. **9.41** requests for exclusion. However, with the introduction of other criteria, e.g. C/I, the situation may change if administrations would choose to exclude the networks identified under coordination arc at the coordination stage. However, it could be expected that administrations would rather do it at the notification stage through the application of RR No. **11.32A**, since the examination under RR No. **11.32A** would also be favourable in the case coordination is not completed. In this case the change may not be significant and as a result, there may be little need for administrations to request exclusion under RR No. **9.41** and the impact on the workload of the Bureau may not be significant.

5/9.1.2/3.2 Technical and operational studies in respect of *resolves* 2

In preparation for WRC-12, the CPM report for "issue 2A" under agenda item 7 was only addressing the value of the coordination arc to trigger coordination in the 6/4 and 14/10/11/12GHz frequency ranges. With Resolution **756 (WRC-12)**, WRC-12 resolves to invite ITU-R to study whether additional reductions in the coordination arcs in RR Appendix **5 (Rev.WRC-12)** are appropriate for the 6/4 GHz and 14/10/11/12 GHz frequency ranges and whether it is appropriate to reduce the coordination arc in the 30/20 GHz frequency range.

In association with the studies conducted under *resolves* 2 the following view was expressed. The reduction of the coordination arc alone as a means to address the difficulty of coordination is not a

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[39] See PDN Report ITU-R S.[RES756].

[40] See PDN Report ITU-R S.[RES756].

sufficient solution for the current coordination procedures. It is a temporary and partial solution and only will be beneficial to some Member States including big satellite operators, while the Member States in the developing countries and small satellite operators will not get the benefit from that action. On the contrary, reduction of the coordination arc alone would increase the burden on administrations to self-identify under RR No. **9.41**. Taking into account that there is no consensus on the applicability of $\Delta T/T$ or C/I or pfd at the stage of RR Articles **9** and **11** to the cases outside the coordination arc, the results become more difficult to manage. Reduction of the coordination arc should be considered together with reviewing other coordination provisions, for example reviewing provision RR No. **9.41**.

Under this view it was emphasized that the issue of reduction of coordination arc was discussed at the last three WRCs. A piecemeal and temporary approach was taken and the issue sent back to the ITU-R Study Groups for further study, which took considerable time and effort of membership in particular of developing countries, some of which did not have sufficient manpower and resources to attend these meetings and to examine the text produced. Consequently, WRC-15 is invited to seriously consider the matter and decide upon the issue definitively in an appropriate, logical, manageable, and practical manner.

The following view was also expressed. While the reduction of the coordination arc alone will not resolve all the difficulties of coordination, it should be considered as part of a series of improvements to the satellite coordination procedures, that are considered under both WRC-15 agenda items 7 and 9.1, issue 9.1.2. There is no reason to prevent the consideration of this issue just because all the other issues under WRC-15 agenda items 7 and 9.1, issue 9.1.2 are not yet resolved. The reduction of the coordination arc is especially aiming at decreasing the amount of coordination requirements, some of which may be triggered even in some cases where the technical and operational environment shows that they may be unnecessary. As this issue is included in the WRC-15 agenda, the Conference will consider the matter and decide upon the issue.

5/9.1.2/3.2.1 Studies on the reduction of coordination arc

Table 5/9.1.2/3-1 provides an overview of the current coordination arcs used in application of RR No. **9.7**.

One study[41] in ITU-R demonstrated that a reduction of 2º in the coordination arc sizes would reduce the number of satellite networks identified for the 6/4 GHz, 14/10/11/12 GHz and 30/20 GHz frequency ranges by 27%, 50% and 19%, respectively (although it may be noted that in every case the networks not identified through the coordination arc criteria become identifiable under RR No. **9.41**). Furthermore, to evaluate the technical impact of a potential reduction of coordination arc values, a study was conducted to determine the minimum orbital separation between neighbouring satellite networks. The results of the study indicate that reducing the coordination arc values in the 6/4 GHz, 14/10/11/12 GHz and 30/20 GHz frequency ranges to 6º, 5º and 4º, respectively, would afford protection to existing satellite networks in at least 80% of all cases.

In a second study[42], an analysis was done comparing the actual 30/20 GHz satellites in operation with the number of 30/20 GHz networks filed at the ITU. It was noted that, while the data from the ITU-R website indicates an enhanced interest in the use of these frequency bands, publically available data indicates that the current deployment of satellites in these frequency bands is not uniformly dense throughout the orbit. This suggests that the 8 degrees coordination trigger is still appropriate. Thus, it does not seem appropriate from an evaluation of the current operational

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41 See PDN Report ITU-R S.[RES756].

42 See PDN Report ITU-R S.[RES756].

situation to reduce the coordination arc in the 29.5-30.0 GHz / 19.7-20.2 GHz frequency bands from its current value as contained in RR Appendix **5**.

It is worth mentioning that a conclusion on a decision to reduce the coordination arc in the Ka-band should not be merely based on the operational networks but also on the results of studies of representative technical elements of Ka-band satellite networks. Further, the smaller number of satellite networks brought into use in the frequency range 30/20 GHz is not the only element to be considered in the establishment of the coordination requirements.

5/9.1.2/3.2.2 Potential impacts of the reduction of the coordination arc on the use of RR No. 9.41

Under *resolves* 2 of Resolution **756 (WRC-12)**, consideration has been given to a further reduction of the coordination arc values in the 6/4 GHz and the 14/10/11/12 GHz frequency ranges and whether it is appropriate to reduce the coordination arc value in the 30/20 GHz frequency range. Any reduction of the coordination arc may have an impact on the use of RR No. **9.41** which is being considered under *resolves* 1 of Resolution **756 (WRC-12)**. By reducing the coordination arc value, the number of satellite networks inside the arc which would be identified as potentially affected by a proposed incoming network would decrease. This reduction of the number of satellite networks identified by the Bureau through the application of the coordination arc approach could lead to an increase of the use of RR No. **9.41** by administrations willing to self-identify or to have some of their satellite networks not identified by the Bureau included in the list of satellite networks to be considered when effecting coordination. However, in practice, it is expected that the number of satellite networks that are actually used to self-identify under RR No. **9.41** will be less than the number of satellite networks that are eligible to be used to self-identify under this provision. This can be explained by the fact that several administrations did choose to rely strictly on the coordination arc approach for the identification of the coordination requirements.

Two studies[43] have shown that an increase in the value of the technical criterion used in application of RR No. **9.41** could reduce the number of potentially affected networks inside the coordination arc (i.e. networks identified by the Bureau as affected for which the $\Delta T/T$ criterion is not exceeded could be excluded of the coordination process upon request by the notifying administration under RR No. **9.41**) or outside the coordination arc (i.e. networks which may be included into the list of affected network under RR No. **9.41**). In one of these studies, an assessment of the impact of the reduction of the coordination arc versus an increase of the $\Delta T/T$ criterion has been provided. The result of this assessment suggests that in practice, a reduction of the coordination arc would have a greater impact in reducing the number of satellite network to be considered when effecting coordination under RR No. **9.7** than an increase of the $\Delta T/T$ criterion used in application of RR No. **9.41**.

The reduction of the coordination arc increases the burden on administrations to self-identify under RR No. **9.41** their affected satellite networks not within the coordination arc, if any. In particular, the non-submission of the appropriate comments within the four month period of the date of publication of the coordination request may leave these networks unprotected. However, although the use of RR No. **9.41** involves the submission of specific information (see the Rule of Procedure (RoP) on RR No. **9.41**) and as such additional efforts from administrations, it is worth mentioning that, at least for the current technical criterion used in application of this provision, the Bureau provides software (The Tab named "Appendix 8" of GIBC software) that allows administrations to identify satellite networks that are eligible for the application of RR No. **9.41** as well as some

[43] See PDN Report ITU-R S.[RES756].

sample calculations. This information can be found in proper folder in two different files named "NTW_OPT.LST" and "APP8_OPT.LST", respectively.

5/9.1.2/4 Regulatory and procedural considerations

Concerns were expressed that the variety of coordination triggers and criteria being considered, different assumptions and including some arbitrary selected values would add more complexity, in some cases if not all, to the already existing complex procedures in application of RR Articles **9** and **11**. This could adversely affect the rights of some administrations in particular those of developing countries. Moreover, the workload of administrations could be increased as a result of application of selected options referred to in this document. The Bureau's workload in terms of application of new procedures and development of associated software would certainly be increased. Backlog in processing of submitted networks, which no longer exists, may reappear as a result of application of new procedures.

5/9.1.2/4.1 Transitional measures

While the number of satellite networks with which newly filed networks need to seek coordination would be reduced, the number of satellite networks with which previously filed networks need to seek coordination under the current rules/criteria would not be changed if the scope of the new rules/criteria is limited to newly examined networks. Furthermore, as for the existing (affected) satellite network, it would be forced to accept the interference from newly filed network while it might still need to coordinate with previously filed networks with date precedence.

Therefore, transition regulations will need to be carefully considered in order to protect existing networks from additional unplanned interference from new networks that use different criteria to establish coordination requirements. Given that decisions of the WRC would not be applicable retroactively, one possible option would be to apply the new regulatory arrangements in this regard to satellite networks for which request for coordination is received by the Bureau after the date of application of these new procedures. With respect to the satellite networks for which request for coordination is received by the Bureau before that date, the regulatory regime in force before that date shall continue to apply.

In addition, the current RR provide some flexibility in the reporting of *C*/*N*, and some networks may have not provided this figure. Furthermore, the current instruction is to report the greater of either the carrier-to-noise ratio required to meet the performance of the link under clear-sky conditions or the carrier-to-noise ratio required to meet the short-time objectives of the link inclusive of necessary margins. However, if the coordination trigger level is changed, and if the coordination criterion becomes *C*/*I*, the required *C*/*N* provided for existing networks may no longer be correct. Thus, if a *C*/*I* criterion is adopted that is based on *C*/*N*, and if the coordination trigger value is changed from 6% $\Delta T/T$, existing networks should be given the opportunity to revise their currently published *C*/*N*, without penalty, in order ensure adequate protection from new networks.

5/9.1.2/4.2 Consistency between RR Articles 9 and 11

Consideration should be given to whether it is necessary or desirable to use the same criteria in RR Articles **9** and **11** when both of them are modified with new conditions.

On one hand, it could seem to be a good idea to align the clauses with each other to avoid the waste of time and energy. Moreover, using a single criterion with respect to RR Articles **9** and **11** could provide a more precise criterion in different coordination stages and that may reduce undue protection requirements and shorten the list of affected networks determined in application of RR No. **9.41** and RR No. **9.7** in cases when the coordination arc criterion is not applicable.

However, it is worth noting that the time to be spent on the examination with respect to RR Article **9** should generally be limited due to the large number of submissions. Also note that the number of applications of RR No. **11.32A** would be less than those of RR Article **9** because a certain number of networks coordination may be complete by then or they do not reach the stage of RR Article **11**. In both cases, the application of RR No. **11.32A** would not be necessary.

Therefore, it could be considered reasonable to apply more protective but simpler and easier procedures to RR Article **9** compared with RR Article **11**. Furthermore, it should be noted that, since WRC-12 decided to reduce the coordination arc by 2 degrees in the 6/4 GHz and 14/10/11/12 GHz frequency ranges, comments under RR No. **9.41** have gotten more important and that the Bureau would subsequently study the comments and publish a definitive list of administrations and corresponding satellite networks with which coordination would be required.

With software tools used by the Bureau for all considered criteria, use of different criteria at different stages of the coordination process would seem not to pose any practical problems.

5/9.1.2/4.3 Procedure for examination under RR No. 11.32A and relevant RR Appendix 4 parameter

In the examination under RR No. **11.32A**, in order to assess the probability of harmful interference generated by a new satellite network into other existing satellite networks, *C*/*N* objectives submitted by responsible administrations for those other networks are used only if they are lower than the corresponding calculated *C*/*N* values for those networks. Otherwise, those calculated *C*/*N* values are used. If no *C*/*N* objectives were submitted by responsible administrations (this was not required in the past) those calculated *C*/*N* values will be used.

When carrying out such calculations, BR computes the *C*/*N* using the maximum power supplied to the input of the antenna (item C.8.a.1/C.8.b.1). In reality, the carrier power supplied to the antenna can be lower than the submitted maximum value and, therefore, required *C*/*I* for the interfered with networks may not be secured and the probability of harmful interference be underestimated. Moreover, if the examination of the newly notified network under RR No. **11.32A** with respect to a certain recorded satellite network leads to a favourable finding and assignment of new satellite network actually caused harmful interference into existing assignments, RR No. **11.42** could not be applied.

Taking the above into account, the following seem to be possible alternatives to overcome this issue:

1 to evaluate the *C*/*I* required by adding *C*/*N* objectives or calculated *C*/*N* (using the minimum power supplied to the input of the antenna (item C.8.c.1)) with a *K* value, generally of either 12.2 or 14.0 dB. *C*/*N* objectives submitted by responsible administrations will be used only if they are lower than the corresponding calculated minimum *C*/*N* values for those networks. Otherwise, those calculated *C*/*N* values would be used. However, it should be noted that the minimum power was not required to be submitted before WRC-95 hence this method may require that such networks would re-submit the required data;

2 to compute the link margin *M* as per the relevant formula of Section 1 of Attachment 1 of Section B3 of the Rules of Procedure by using the maximum value for the wanted signal *C* (item C.8.a.1/C.8.b.1) for both the $(C/I)_a$ and the (*C*/*N*) components;

3 to apply an analysis based on $\Delta T/T$; however, it is noted that such an analysis may provide results different from those obtained through an examination using a *C*/*I* criterion which takes into account bandwidth advantage factor, other link parameters and additional margins which are stipulated in section B3 of the Rule of Procedure;

4 to use a pfd-based criterion in the examination under RR No. **11.32A**.

It is noted that the application of appropriate pfd masks (as per method 4 above) could solve this problem in a simple manner. Appropriate pfd criteria should be derived from typical characteristics of FSS networks and adequate noise power apportionment for single-entry interference (i.e. $\Delta T/T = 6\%$) and these values for C and Ku-bands can be found in the chairman's report of WP 4A in previous study period (see Doc. 4A/595, Annex 12).

5/9.1.2/4.4 Examples of regulatory solutions

The specific values included in each of the options below were those used during the development of each option. Other specific values could be used for any of these options.

5/9.1.2/4.4.1 Regulatory and procedural considerations in respect of *resolves* 1

5/9.1.2/4.4.1.1 Option 1A

Regulatory provisions of Option 1A are aimed at facilitation of coordination in difficult cases related to compatibility of notified inhomogeneous satellite networks, and at efficiency of the frequency resource of the unique geostationary orbit. The effect of the two factors on the future development of satellite communications seems to be of far more importance than proposals for savings in correspondence efforts between the Bureau and administrations for international frequency coordination of submitted satellite networks.

Under this option, it is proposed to retain the existing criterion *C*/*I* for examination under RR No. **11.32A** for frequency bands under consideration and also base the examination under RR Nos. **9.7** and **9.41** on the same *C*/*I* assessment.

This option would involve retention of RR Nos. **9.7**, **9.41** and **11.32A** essentially as today. However, the technical criteria associated with the various provisions would be modified as follows:

– For the identification of coordination requirements by the Bureau under RR No. **9.7**, the use of the coordination arc would be retained where currently applicable. In frequency bands where the coordination arc criterion is not applicable, the current $\Delta T/T > 6\%$ criterion would be replaced by a $C/I < C/N + X$[44] dB criterion.

– For inclusion/exclusion in/from the coordination under RR No. **9.41**, the current $\Delta T/T > 6\%$ criterion would be replaced by a $C/I < C/N + X$[44] dB criterion as currently in Section B3 of the RoP. This criterion would be used for all services in all frequency bands covered by RR No. **9.41**.

– Examination of probability of harmful interference under RR No. **11.32A** would generally be based upon the same *C*/*I* criterion as that used under RR No. **9.41** and RR No. **9.7** (in frequency bands where the coordination arc criterion is not applicable), but would be transferred from the RoP to the RR.

It is proposed to replace $\Delta T/T$ criterion with *C*/*I* one, as unlike $\Delta T/T$, criterion *C*/*I* considers power parameters of a satellite link, such as *C*/*N* ratio, level of wanted signal etc., and therefore it is more exact and consequently it is used by administrations at the international coordination of satellite

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[44] 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T = 20\%$, X = 7.0 dB. If other levels of interference are to be considered, *C*/*I* may be adjusted by $C/I_{Y\%} = C/I_{20\%} - 10\log(Y/20)$.

Consequential aggregate effect of this increase in single-entry interference criterion has not yet been fully evaluated.

networks. Furthermore, an analysis carried out on a *C/I* criterion, as opposed to a pfd criterion, is not based on pre-determined parameters of the networks.

Table 5/9.1.2/4-1 summarizes the changes introduced by this option compared to the current procedures.

TABLE 5/9.1.2/4-1

		Coordination stage			Application of RR No. **11.32A** at notification stage
		First step: Bureau identification of potentially affected administrations		Second step: possible application of RR No. **9.41**	
Current	Type of criterion	Coordination arc	$\Delta T/T$	$\Delta T/T$	*C/I*
	Criterion value	±8° in C band, ±7° in Ku-band, ±8° in Ka-band, ±16° in Ka-band and above	–	$\Delta T/T > 6\%$	Based on Part B, Section B3 of the RoP *C/N* + 12.2 dB
	Criterion value	–	$\Delta T/T > 6\%$	–	
Possible new criteria	Type of criterion	Coordination arc	*C/I*	*C/I*	*C/I*
	Criterion value	To be further studied (see section 5/9.1.2/4.2 above)	–	$C/I < C/N$[45]$+ X$[46] dB	MOD RR Appendix **8** Based on Part B, Section B3 of the RoP *C/N* + X dB[9]
	Criterion value	–	$C/I < C/N+X$[9] dB	–	

NOTE: RoP related to RR Nos. **9.41** and **11.32A** need to be corrected.

EXAMPLE OF REGULATORY TEXT IN RESPECT OF OPTION 1A

NOC

ARTICLE 9

Procedure for effecting coordination with or obtaining agreement of other administrations[1, 2, 3, 4, 5, 6, 7, 8, 8*bis*] (WRC-12)

Reasons: No changes to the provisions of RR Article **9** in respect of Option 1A.

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[45] *C/N* should be defined in accordance with the proposed Appendix **8 (Rev.WRC-15)**.

It is proposed to modify BR's Space Capture software in such a way that it would calculate and show the calculated *C/N* value and include it in the notice database.

[46] 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T$ = 20%, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%} = 7.0 - 10\log(Y/20)$.

ARTICLE 11

Notification and recording of frequency assignments[1, 2, 3, 4, 5, 6, 7, 7*bis*] (WRC-12)

Section II − Examination of notices and recording of frequency assignments in the Master Register

MOD

11.32A *c)* with respect to the probability of harmful interference that may be caused to or by assignments recorded with a favourable finding under Nos. **11.36** and **11.37** or **11.38**, or recorded in application of No. **11.41**, or published under Nos. **9.38** or **9.58** but not yet notified, as appropriate, for those cases for which the notifying administration states that the procedure for coordination under Nos. **9.7**, **9.7A**, **9.7B**, **9.11**, **9.12**, **9.12A**, **9.13** or **9.14**, could not be successfully completed (see also No. **9.65**);[14, 14*bis*] or (WRC-2000)

NOC

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[14] **11.32A.1**

ADD

[14*bis*] **11.32A.2** The calculation method to assess harmful interference and the criteria for the formulation of the findings of the Bureau for the coordination under No. **9.7** are contained in Appendix **8**.

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APPENDIX 5 (REV.WRC-~~12~~15)

Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9[47]

TABLE 5-1 (REV.WRC-~~12~~15)
Technical conditions for coordination
(see Article **9**)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO	A station in a satellite network using the geostationary-satellite orbit (GSO), in any space radiocommunication service, in a frequency band and in a Region where this service is not subject to a Plan, in respect of any other satellite network using that orbit, in any space radiocommunication service in a frequency band and in a Region where this service is not subject to a Plan, with the exception of the coordination between earth stations operating in the opposite direction of transmission	1) 3 400-4 200 MHz 5 725-5 850 MHz (Region 1) and 5 850-6 725 MHz 7 025-7 075 MHz 2) 10.95-11.2 GHz 11.45-11.7 GHz 11.7-12.2 GHz (Region 2) 12.2-12.5 GHz (Region 3) 12.5-12.75 GHz (Regions 1 and 3) 12.7-12.75 GHz (Region 2) and 13.75-14.5 GHz	i) Bandwidth overlap, and ii) any network in the fixed-satellite service (FSS) and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS i) Bandwidth overlap, and ii) any network in the FSS or broadcasting-satellite service (BSS), not subject to a Plan, and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±7° of the nominal orbital position of a proposed network in the FSS or BSS, not subject to a Plan		With respect to the space services listed in the threshold/condition column in the bands in 1), 2), 3), 4), 5), 6), 7) and 8), an administration may request, pursuant to No. **9.41**, to be included in requests for coordination, indicating the networks for which the value of ~~$\Delta T/T$~~ C/I calculated by the method in ~~§ 2.2.1.2 and 3.2 of~~ Appendix **8** **(Rev.WRC-15)** ~~exceeds 6%~~is lower than the appropriate criterion (C/N + X[48] (dB)). When the Bureau, on request by an affected administration, studies this information pursuant to No. **9.42**, the calculation method given in ~~§ 2.2.1.2 and 3.2 of~~ Appendix **8** **(Rev.WRC-15)** shall be used.

[47] See Resolution **[A912] (WRC-15).**

[48] 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T$ = 20%, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%}$ = 7.0 – 10log(Y/20).

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		3) 17.7-20.2 GHz, (Regions 2 and 3), 17.3-20.2 GHz (Region 1) and 27.5-30 GHz	i) Bandwidth overlap, and ii) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS		
		4) 17.3-17.7 GHz (Regions 1 and 2)	i) Bandwidth overlap, and ii) a) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the BSS, or b) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS		

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		5) 17.7-17.8 GHz	i) Bandwidth overlap, and ii) a) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the BSS, or b) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS NOTE – No. **5.517** applies in Region 2.		
		6) 18.0-18.3 GHz (Region 2) 18.1-18.4 GHz (Regions 1 and 3)	i) Bandwidth overlap, and ii) any network in the FSS or meteorological-satellite service and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS or the meteorological-satellite service		

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		6*bis*) 21.4-22 GHz (Regions 1 and 3)	i) Bandwidth overlap; and ii) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±12° of the nominal orbital position of a proposed network in the BSS (see also Resolutions **554 (WRC-12)** and **553 (WRC-12)**).		No. **9.41** does not apply.
		7) Bands above 17.3 GHz, except those defined in § 3) and 6)	i) Bandwidth overlap, and ii) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS (see also Resolution **901 (Rev.WRC-07)**)		
		8) Bands above 17.3 GHz except those defined in § 4), 5) and 6*bis*)	i) Bandwidth overlap, and ii) any network in the FSS or BSS, not subject to a Plan, and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±16° of the nominal orbital position of a proposed network in the FSS or BSS, not subject to a Plan, except in the case of a network in the FSS with respect to a network in the FSS (see also Resolution **901 (Rev.WRC-07)**)		

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No.**9.7** GSO/GSO (*cont.*)		9) All frequency bands, other than those in 1), 2), 3), 4), 5), 6), 6*bis*), 7) and 8), allocated to a space service, and the bands in 1), 2), 3), 4), 5), 6), 6*bis*), 7) and 8) where the radio service of the proposed network or affected networks is other than the space services listed in the threshold/ condition column, or in the case of coordination of space stations operating in the opposite direction of transmission	i) Bandwidth overlap, and ii) Value of *C/I* calculated by the method in Appendix **8 (Rev.WRC-15)**, lower than the appropriate criterion *C/N*+X (dB)[49] ~~*ΔT/T* exceeds 6%~~	Appendix **8**	In application of Article 2A of Appendix 30 for the space operation functions using the guardbands defined in § 3.9 of Annex 5 of Appendix 30, the threshold/condition specified for the FSS in the bands in 2) applies. In application of Article 2A of Appendix 30A for the space operation functions using the guardbands defined in § 3.1 and 4.1 of Annex 3 of Appendix 30A, the threshold/condition specified for the FSS in the bands in 7) applies

NOTE: Depending upon decisions of WRC-15 in respect of *resolves* 2 of Resolution **756 (WRC-12)**, the numerical values for the size of the coordination arc in one or more of the listed frequency bands of Table 5-1 may change. This option is neutral in respect of the size of the coordination arc and decisions on the size of the coordination arc will not lead to a need for consequential changes in respect of this option or vice versa.

[49] 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T$ = 20%, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%}$ = 7.0 – 10log(Y/20).

MOD

APPENDIX 8 (REV.WRC-~~03~~15)

Method of calculation for determining if coordination is required or if there is a probability of harmful interference between geostationary-satellite networks sharing the same frequency bands

ADD

Calculation methodology for calculating *C*/*I* ratios in respect of determination of coordination requirements or the probability of harmful interference between space networks

1 Introduction

The criterion based on calculation of carrier/interference (*C*/*I*) ratios is used for identification of coordination requirements in application of the provisions:

– No. **9.7** when Bureau identifies affected administrations in cases where the coordination arc criterion is not applicable;

– No. **9.41** at giving technical reasons for including in/excluding out of the list of affected administrations/networks satellite networks within/beyond coordination arc;

– No. **11.32A** with respect to the probability of harmful interference.

The description of the calculation method and criteria to be used for the interference assessment as well as the findings to be formulated with respect to coordination of networks under No. **9.7** are as follows.

2 Probability of harmful interference

The Bureau, in performing its mandatory tasks relating to the application of the above-mentioned provisions, and administrations in applying No. **9.41**, shall proceed as follows:

2.1 Recommendation ITU-R S.741-2 should be used to examine the subject assignments with respect to the provisions of Nos. **9.7**, **9.41** and **11.32A**.

2.2 The Bureau/administrations when determining the probability of harmful interference shall use either the single-entry limits or the mutually agreed criteria provided by the administrations concerned for accepted interference, as appropriate.

2.2.1 To examine the subject assignments with respect to the provisions of Nos. **9.7** and **9.41**, the Bureau/administrations shall use the single-entry limits defined in Table 1, which is derived from Table 2 of Recommendation ITU-R S.741-2, together with the information submitted in accordance with Appendix **4**:

a) the probability of harmful interference is considered to be negligible if the interference is less than or equal to the single-entry interference limits indicated in Table 1. In this case the finding shall be favourable, and coordination is not required;

b) the probability of harmful interference is considered not to be negligible, if the interference is greater than the single-entry interference limits defined in Table 1. In this

case, the finding shall thus be unfavourable, and frequency assignments should be taken into account in coordination.

2.2.2 To examine the subject assignments with respect to the provisions of No. **11.32A**, the Bureau shall use the mutually agreed criteria provided by the administrations concerned for accepted interference in the format appearing in Table 2 of Recommendation ITU-R S.741-2, or, in the absence of such information, the Bureau shall use the single-entry limits defined in Table 1, together with the information submitted in accordance with Appendix **4**.

2.2.2.1 In the case where this information is provided by the administrations concerned:

a) the probability of harmful interference is considered to be negligible if the *C*/*I* calculation shows that the applicable criteria for a particular examination between two networks concerned are satisfied. In this case the finding in respect of No. **11.32A** shall be favourable and the assignment shall be recorded in the Master Register;

b) the probability of harmful interference is considered not to be negligible, if the *C*/*I* calculation shows that the applicable criteria for a particular examination between two networks concerned are not satisfied. Accordingly, the finding shall be unfavourable and the notice shall be returned with an indication of the appropriate actions.

2.2.2.2 In the case where this information is not provided by the administrations concerned:

a) the probability of harmful interference is considered to be negligible if the interference is less than or equal to the single-entry interference limits indicated in Table 1. In this case the finding shall be favourable, and the assignment shall be recorded in the Master Register;

b) the probability of harmful interference is considered not to be negligible, if the interference is greater than the single-entry interference limits indicated in Table 1. Accordingly the finding shall be unfavourable and the notice shall be returned with an indication of the appropriate actions.

TABLE 1

Single-entry interference (SEI) protection criteria

Interfering carrier type **Desired carrier type**	**Analogue (TV-FM) or other**	**Digital**	**Analogue (other than TV-FM)**
Analogue (TV-FM)	C/N + 14 (dB)		
Digital	If DeNeBd ≤ InEqBd then C/N + 9.4 + 3.5 log (δ) − 6 log (i/10) (dB) (i.e. C/N + 5.5 + 3.5 log (DeNeBd (MHz))) Otherwise if DeNeBd > InEqBd then C/N + 12.2 (dB)	C/N + K (dB)*	C/N + 12.2 (dB)
Analogue (other than TV-FM)	13.5 + 2 log (δ) − 3 log (i/10) (dB) (i.e. 11.4 + 2 log (DeNeBd (MHz)))	C/N + 12.2 (dB)	
Other	13.5 + 2 log (δ) − 3 log (i/10) (dB) (i.e. 11.4 + 2 log (DeNeBd (MHz)))	C/N + 14 (dB)	

where:

C/*N*: ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems

DeNeBd: necessary bandwidth of desired carrier (Appendix **4**, Annex 2, item C.7.a)

InEqBd: equivalent bandwidth of interfering carrier (equal to total power to power density ratio (see Appendix **4**, Annex 2, items C.8.a.1 and C.8.a.2 respectively))

δ: ratio of desired signal bandwidth to peak-to-peak deviation of the TV carrier caused by the energy dispersal signal (a peak-to-peak deviation of 4 MHz is used in all cases)

i: pre-demodulation interference power in the desired signal bandwidth expressed as a percentage of the total pre-demodulation noise power (a value of 20 is used in all cases)

K factor defined in Table **5-1** of Appendix **5**.

*NOTE: Factor K = X dB (criterion $C/I < C/N$ + X (dB)) shall be applied at examination of frequency assignments (digital carrier case) between frequency assignments of new networks whose coordination requests were submitted to the Bureau after closing date of WRC-15.

7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T$ = 20%, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%} = 7.0 - 10\log(Y/20)$.

Factor K = 12.2 dB (criterion $C/I < C/N$ + 12.2 (dB)) shall continue to be applied to check interference in respect of frequency assignments (digital carrier case) of networks whose coordination requests were submitted to the Bureau before closing date of WRC-15.

3 Methodology

To perform the above-mentioned compatibility analysis the following methodology is used.

The methodology is based on Recommendation ITU-R S.741-2. A set of carrier-to-interference (*C*/*I*) calculations are performed following the geometrical considerations of Recommendation ITU-R S.740 and an interference adjustment factor is calculated as shown below to take into consideration the frequency offset situations as well as the difference in the bandwidths between the wanted and the interfering carriers. These *C*/*I* values (*C*/*I* calculated) are then compared with the required *C*/*I* values (*C*/*I* required) derived from the criteria appearing in Table 1 which contains a set of single-entry interference criteria to protect different types of carriers. In the case of required *C*/*I* values agreed by administrations and communicated to the Bureau (see § 2.2.2), the calculated *C*/*I* values are compared with these mutually agreed *C*/*I* values.

Thereafter, a set of margins *M* (*C*/*I* calculated – *C*/*I* required) are derived. It should be noted that to evaluate the *C*/*I* value required for each test point, a set of carrier-to-noise ratio (*C*/*N*) objectives are used (performance) and a K value, generally of either 7.0, 12.2 or 14.0 dB, is added in accordance with the above-mentioned Table 1. It should also be noted that these values correspond to a maximum permissible single-entry interference of 20%, 6% or 4% correspondingly of the total noise power *N* of the protected assignments (performance).

The *C*/*N* objectives, submitted to the Bureau in accordance with Appendix **4** (Annex 2 item C.8.e.1) by the administration responsible for the satellite network under examination, will be used to assess the probability of harmful interference received by this satellite network. To assess the probability of harmful interference generated by this satellite network into other satellite networks, *C*/*N* objectives submitted by responsible administrations for those other networks will be used only if

they are lower than the corresponding calculated *C*/*N* values for those networks. Otherwise, those calculated *C*/*N* values will be used. If no *C*/*N* objectives were submitted by responsible administrations those calculated *C*/*N* values will be used.

Table 1 and Recommendation ITU-R S.741-2 define *C*/*N* as a "ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems". Therefore, and to comply with this definition, an additional margin defined by wanted emissions type will be added to the margins calculated on the basis of the internal system noise values provided by the concerned administrations. Attachment 2 contains the calculation methodology used for deriving the above-mentioned additional margin.

3.1 Interfering cases

Although most of the cases consider digital carriers, but actions for different interference cases have been also considered for generality. Table 2 presents a summary of the different interfering situations to be dealt with when performing *C*/*I* calculations.

TABLE 2

Interference cases

Desired / **Interfering**	**Digital**	**Analogue (TV-FM)**	**Analogue (other than TV-FM)**	**Other**
Digital	Use *C*/*I* plus interference adjustment factor[1] (I)	Use *C*/*I* plus interference adjustment factor[1] (II)	Use *C*/*I* plus interference adjustment factor[1] (III)	Use *C*/*I* plus interference adjustment factor[1] (XI)
Analogue (TV-FM)	Use *C*/*I* plus interference adjustment factor[2] (IV)	*Co-frequency:* use *C*/*I* plus interference adjustment factor[1] (X) *Non co-frequency:* use relative protection ratio mask[3] (V)	Use *C*/*I* plus interference adjustment factor[2] (VI)	Use *C*/*I* plus interference adjustment factor[2] (XII)
Analogue (other than TV-FM)	Use *C*/*I* plus interference adjustment factor[2] (VII)	Use *C*/*I* plus interference adjustment factor[2] (VIII)	Use *C*/*I* plus interference adjustment factor[2] (IX)	Use *C*/*I* plus interference adjustment factor[2] (XIII)
Other	Use *C*/*I* plus interference adjustment factor[2] (XIV)	Use *C*/*I* plus interference adjustment factor[2] (XV)	Use *C*/*I* plus interference adjustment factor[2] (XVI)	Use *C*/*I* plus interference adjustment factor[2] (XVII)

1 Interference adjustment factor for Cases I, II, III, X and XI is the same (see § 3.8.1).

2 Interference adjustment factor for Cases IV, VI to IX and XII to XVII is the same (see § 3.5).

3 See § 3.10.

The selection of an interference case defined in Table 2 requires the identification of the type of each carrier, taking into account the information submitted to the Bureau by administrations in accordance with Appendix **4** (i.e. the class of emission as defined in Annex 2 item C.7.a).

3.2 Margin *M, C/I, C/N* algorithms

The algorithms described shall be used to evaluate compliance with the mutually accepted interference criteria or with the single-entry interference limits established in Table 1.

3.3 Single channel per carrier (SCPC) cases

When dealing with composite interference from a number of narrow-band carriers such as a transponder loaded with SCPC carriers the assumption is made, in the absence of more detailed data from administrations, that the interfering satellite has its transponder fully loaded with SCPC carriers and the individual carriers can be replaced with one wideband carrier which has a total power equal to the sum of the powers of the individual SCPC carriers. The protection ratios given in Recommendation ITU-R S.671 are used to protect SCPC transmissions interfered with by analogue television carriers only modulated with energy dispersal signals.

3.4 Interference between analogue FDM-FM signals (Case (IX) in Table 2)

When dealing with FDM-FM carriers, and to find out the resulting margin, the *C*/*I* ratio is calculated and compared with the required *C*/*I*. However a *C*/*N* + *K* type protection criteria is developed based on the equations of Recommendation ITU-R SF.766 which are required to calculate the *B* factor (interference reduction factor). In the absence of detailed information for the calculation of the *B* factor, the interference adjustment factor described in § 3.5 shall be used.

3.5 Other interference cases

For cases (IV), (VI), (VII), (VIII), IX and (XI) to (XVII) in Table 2, the interference adjustment factor mentioned in § 3 shall be used. In calculating this factor, if the interfering power spectrum is not known, a worst-case calculation of interference can be made with the approximation that the power spectral density of the interfering carrier is constant over the bandwidth of the desired carrier and is equal to the maximum value. The interfering power can then be calculated as the product of the maximum interfering power spectral density and the occupied bandwidth of the desired carrier, provided the result does not exceed the total power of the interfering carrier, see Recommendation ITU-R S.741-2.4

3.6 Margin algorithm

To compute the margins, it is necessary first to determine the minimum required $\left(\frac{C}{I}\right)_m$ value,

which is a function of the *C*/*N* and the *K* factor:

$$\left(\frac{C}{I}\right)_m = \left(\frac{C}{N}\right) + K,$$

where:

$\left(\frac{C}{I}\right)_m$: minimum required *C/I* value (dB)

$\left(\frac{C}{N}\right)$: *C*/*N* objective or calculated *C*/*N* value(dB) (see the 4th paragraph of § 3)

K : factor used in computing the minimum required *C*/*I* (dB) value (see Table 1), defining permissible level of single-entry interference and depending on the modulation characteristics of the desired signals (see Recommendations ITU-R S.483 and ITU-R S.523).

The margin is the difference between the calculated *C*/*I* value and the required *C*/*I* value:

$$M = \left(\frac{C}{I}\right)_a - \left(\frac{C}{I}\right)_m$$

where:

M : margin (dB)

$\left(\frac{C}{I}\right)_a$: adjusted value of calculated *C*/*I*, taking into account the interference adjustment factor (dB)

$\left(\frac{C}{I}\right)_m$: is the minimum required *C*/*I* value (dB) computed above.

Since $\left(\frac{C}{I}\right)_m$ and $\left(\frac{C}{I}\right)_a$ values will vary depending on the geographical location, both values are computed:

– at the geographical locations of the associated specific earth stations, if any, or

– in case of associated typical earth stations, at the test point located within the service area where the $\left(\frac{C}{I}\right)_a$ value is minimum.

$$M = \left(\frac{C}{I}\right)_a - \left(\frac{C}{N}\right) - K$$

3.7 The $\left(\frac{C}{I}\right)_a$ algorithm for interfering situations

The basic *C*/*I* is adjusted as follows:

$$\left(\frac{C}{I}\right)_a = \left(\frac{C}{I}\right)_b - I_a$$

where:

$\left(\frac{C}{I}\right)_a$: adjusted *C*/*I* value, taking into account the interference adjustment factor (dB)

$\left(\frac{C}{I}\right)_b$: basic calculated *C*/*I* value, before taking into account the interference adjustment factor (dB)

I_a : interference adjustment factor (dB).

The adjusted *C*/*I* values are determined separately for the uplink and downlink, keeping in mind that the interference adjustment factor may be different for the uplink and for the downlink.

The overall *C*/*I* value is also computed. If there are uplink calculations only (i.e. no downlink for the desired or interfering signal, or both, or no downlink frequency overlap between the desired and interfering signals), the values of the overall *C*/*I* are simply the uplink values of *C*/*I*. Similarly, if

there are downlink calculations only (i.e. no uplink for the desired or interfering signal, or both, or no uplink frequency overlap between the desired and interfering signals), the values of the overall *C*/*I* are simply the downlink values of *C*/*I*. However, if the desired and interfering signals have both an uplink and a downlink, the overall *C*/*I* value is computed for each downlink test point using the worst-case uplink *C*/*I* value and the individual downlink *C*/*I* values:

$$\left(\frac{C}{I}\right)_T = -10\log_{10}\left[10^{-\frac{\left(\frac{C}{I}\right)_u}{10}} + 10^{-\frac{\left(\frac{C}{I}\right)_d}{10}}\right]$$

where:

$\left(\frac{C}{I}\right)_T$: overall *C*/*I* value of for a particular downlink test point (dB)

$\left(\frac{C}{I}\right)_u$: worst-case uplink *C*/*I* value at any uplink test point (dB)

$\left(\frac{C}{I}\right)_d$: downlink *C*/*I* for a particular downlink test point (dB).

3.8 Determination of interference adjustment factor

3.8.1 Interference from noise-like digital carriers (interference adjustment factor 1)

The current version of Recommendation ITU-R S.741-2 covers the case of co-frequency interference from noise-like digital carriers. For non-co-frequency interference, an interference adjustment factor (or bandwidth advantage factor) is required to use applying a factor A defined below (mentioned as I_a above).

For the case of frequency offset between carriers, the resultant *C*/*I* ratio can be determined by the following equation:

$$C/I = 10 \log (c/i) - A$$

where *A* is the bandwidth advantage factor (dB).

The factor A is the ratio of the interfering carrier power contained in the desired signal bandwidth to the total interfering carrier power under the assumption that the interfering carrier has uniform power spectral density across its occupied bandwidth.

3.8.2 Interference from noise-like analogue carriers (interference adjustment factor 2)

For these cases, the resultant *C*/*I* can be determined by using the equation in § 3.8.1 where the factor A is the ratio of the interfering carrier power contained in the desired signal bandwidth to the interfering carrier power with the approximation that the power spectral density of the interfering carrier is constant over the bandwidth of the desired carrier and is equal to the maximum value (see § 3.5).

3.9 The *C*/*N* algorithm for satellite system

The algorithm for *C*/*N* requires the computation of the value of *N*, as follows:

$$N = -228.6 + 10\left[\log_{10}(T_R) + 6 + \log_{10}(BW)\right]$$

where:

N : noise value (dBW)

T_R : receiving system noise temperature (K) (space station or earth station)

BW : bandwidth (MHz).

The value of N is determined for the uplink (if there is an uplink) and for the downlink (if there is a downlink) for the desired system. Once N is determined, C/N will be computed at each uplink test point (if there is an uplink) and each downlink test point (if there is a downlink):

$$\frac{C}{N} = C - N \text{ (dB)}$$

where:

C : carrier (dBW)

N : noise value (dBW) computed above.

The overall C/N is also computed. If there is an uplink only, the values of the overall C/N are simply the uplink values of C/N. Similarly, if there is a downlink only, the values of the overall C/N are simply the downlink values of C/N. However, if there is both an uplink and a downlink, the overall C/N value is computed for each downlink test point using the *worst-case* uplink C/N value and the individual downlink C/N values:

$$\left(\frac{C}{N}\right)_T = -10 \log_{10}\left[10^{-\frac{\left(\frac{C}{N}\right)_u}{10}} + 10^{-\frac{\left(\frac{C}{N}\right)_d}{10}}\right]$$

where:

$\left(\frac{C}{N}\right)_T$: overall C/N value of for a particular downlink test point (dB)

$\left(\frac{C}{N}\right)_u$: worst-case uplink C/N value at any uplink test point (dB)

$\left(\frac{C}{N}\right)_d$: downlink C/N value for a particular downlink test point (dB).

3.10 Determination of relative protection ratio for Case (V) in Table 2 (TV-FM) into (TV-FM)

When dealing with a non-co-frequency interfering situation from a TV-FM carrier into another TV-FM carrier, the Radiocommunication Bureau/administrations are using the protection ratio masks defined in the Rules of Procedure relating to § 3.5.1 and § 3.8 of Annex 5 to Appendix **30** for the same case of interference, as appropriate. The resulting protection ratio relaxation is applied to the K factor of 14.0 dB (see Recommendation ITU-R S.483).

ATTACHMENT 1

Used parameters and calculation of the wanted and the interfering carrier levels for cases of conventional and reverse band sharing situations (Cases 1 and 2)

[TBD]

ATTACHMENT 2

Additional margins to be taken into consideration

1 Introduction

To finally assess the interfering effect on a given emission, it is necessary to adjust the resulting margins taking into consideration the definition of *C*/*N* which is necessary to derive the required single-entry interference levels for FSS carriers (see Table 1). In Table 1, *C*/*N* is defined as: "ratio (dB) of carrier to total noise power which includes all internal system noise and interference from other systems". Therefore, and to comply with this definition, an additional margin defined by wanted emissions will be added to the margins calculated on the basis of the internal system noise values provided by the concerned administrations.

2 Calculations performed according to No. 1.174

No. **1.174** defines the equivalent satellite link noise temperature as follows:

> "The noise temperature referred to the output of the receiving antenna of the *earth station* corresponding to the radio frequency noise power which produces the total observed noise at the output of the *satellite link* excluding the noise due to *interference* coming *from satellite links* using other *satellites* and from terrestrial systems."

The internal system noise temperature values provided by the administrations to derive the internal system noise, *N*, i.e. T_s and T_e are defined as follows:

"T_s : the receiving system noise temperature of the space station, referred to the output of the receiving antenna of the space station (K)"

"T_e : the receiving system noise temperature of the earth station, referred to the output of the receiving antenna of the earth station (K)."

The above-mentioned values are combined (see Recommendation ITU-R S.738) to derive T_{min}, lowest *equivalent satellite link noise temperature*, as follows:

$$T_{min} = T_e + \gamma_{min}\, T_S + T_a,$$

where:

T_a : other internal noise

γ_{min} : minimum transmission gain of a specific satellite link subject to interference.

3 Noise to be calculated

To be in accordance with Recommendation ITU-R S.741-2 it seems necessary to add to the values of *N* calculated on the basis of T_e and T_s mentioned above, the maximum permissible level of aggregate interference caused by other space networks (as appears in Recommendations

ITU-R S.466 (for FDM-FM telephony), ITU-R S.483 (for TV analogue) and ITU-R S.523 (for digital emissions)) as well as the contribution of terrestrial emissions sharing the same frequency bands.

4 Calculations of additional margins

4.1 Telephony FDM-FM

4.1.1 Aggregate interference produced by other space networks sharing the same frequency band

In accordance with Recommendation ITU-R S.466, in frequency bands in which the network does not practice frequency reuse: the aggregate interference noise power should not exceed 2 500 pW0p, psophometrically weighted one minute mean power for more than 20% of any month. This amount corresponds to 25% of the allowable noise power of 10 000 pW0p established by Recommendation ITU-R S.353 for the same percentage of time.

4.1.2 Maximum allowable values of aggregate interference from radio-relay systems in a telephone channel of a system in the FSS

In accordance with Recommendation ITU-R SF.356 the interference caused by the aggregate of the transmitters of radio-relay stations should not exceed 1 000 pW0p psophometrically weighted one minute mean power for more than 20% of any month. This amount corresponds to 10% of the allowable noise power of 10 000 pW0p established by Recommendation ITU-R S.353 for the same percentage of time.

4.1.3 Calculation of the additional margin

N_{tot} : total link noise including all internal noise and interference from other systems

N_i : link internal noise

X : noise due to interference from other systems

then:

$$N_{tot} = N_i + X$$

where:

$$X = (0.25 + 0.1)\, N_{tot}$$

Therefore:

$$N_{tot} = N_i + 0.35\, N_{tot}$$

$$N_{tot}(1 - 0.35) = N_i$$

$$N_{tot} = 1.53\, N_i$$

Additional margin: $10 \times \log(1.53) = 1.87$ dB.

In the absence of sufficient information to calculate an additional margin for cases in which uplink and downlink are treated independently, e.g. telemetry and telecommand signals, the initial margins will be used, i.e. no additional margin will be considered for these cases.

4.2 Digital emissions

4.2.1 Aggregate interference produced by other space networks sharing the same frequency band

In accordance with Recommendation ITU-R S.523, in frequency bands in which the network does not practice frequency reuse: the aggregate interference power level averaged over any 10 min, should not exceed, for more than 20% of any month, 25% of the total noise power level at the input to the demodulator that would give rise to a bit error ratio of 1 in 10^6 as it is established by Recommendation ITU-R S.522 for the same percentage of time.

4.2.2 Maximum allowable values of aggregate interference from radio-relay systems into systems in the FSS, employing 8-bit PCM encoded telephony

In accordance with Recommendation ITU-R SF.558 interference caused by the aggregate of the transmitters of radio-relay stations, averaged over any 10 min, should not exceed, for more than 20% of any month, 10% of the total noise power at the input of the demodulator that would give rise to a bit error ratio of 1 in 10^6 as it is established by Recommendation ITU-R S.522 for the same percentage of time.

4.2.3 Calculation of the additional margin

The same values as in § 4.1.3 are obtained (1.87 dB).

Note: A possibility to calculate additional margins taking into account sharing of interference budget established by Recommendation ITU-R S.1432 should be determined. This may be subject to studies by WP 4A.

4.3 Analogue TV

4.3.1 Aggregate interference produced by other space networks sharing the same frequency band

In accordance with Recommendation ITU-R S.483, the aggregate interference noise power should not exceed 10% of the permissible video noise in the hypothetical reference circuit for more than 1% of the month.

4.3.2 Maximum allowable values of aggregate interference from radio-relay systems into FSS analogue video channel

No recommendations have been arrived at yet for interference from transmitters of the fixed service into FSS analogue video channel.

4.3.3 Calculation of the additional margin

$$N_{tot} = N_i + 0.1\ N_{tot}$$

$$N_{tot}(1 - 0.1) = N_i$$

$$N_{tot} = 1.11\ N_i$$

Additional margin: $10 \times \log(1.11) = 0.46$ dB.

5 Based on the above a value of 0.46 dB should be added to the margins involving wanted analogue TV emissions and 1.87 dB for digital and other wanted emissions.

ATTACHMENT 3

MOD

1 Introduction

~~The method of calculation for determining if coordination is required under provision No. **9.7** is based on the concept that the noise temperature of a system subject to interference increases as the level of the interfering emission increases. It can, therefore, be applied irrespective of the modulation characteristics of these satellite networks, and of the precise frequencies used.~~

~~In this method, the apparent increase in the equivalent satellite link noise temperature resulting from an interfering emission of a given system is calculated (see § 2 below) and the ratio of this increase to the equivalent satellite link noise temperature, expressed as a percentage, is compared to a threshold value (see § 3 below).~~

Following is the methodology for calculation of apparent increase in the equivalent noise temperature of satellite link subject to interference, because the criterion for permissible single-entry interference $\Delta T/T$ is a key indicator to be relied on in the calculation of either protection ratios $I/(N + I)$ or C/I.

NOC

2 Calculation of the apparent increase in equivalent noise temperature of the satellite link subject to an interfering emission

SUP

Sections 3 and 4

NOC

ANNEXES I, II, III

MOD

ANNEX IV

Example of an application of Appendix 8 (Rev.WRC-15)

~~1 General~~

~~In this example of Case I (see § 2.2.1), two identical satellite networks each with a simple frequency-changing transponder and a global coverage antenna are assumed.~~

~~All topocentric angles θ_t are assumed to be equal to 5°.~~

~~For this angular separation and for an earth station antenna with D/λ greater than 100, the reference radiation pattern $(32 - 25 \log \theta_t)$ gives a gain of 14.5 dB in the direction of the satellite of the other network.~~

The input data are furnished in § 2 below and are expressed in decibels except for the parameters T and θ_t. In § 3 the calculations are performed in decibels.

It may be noted that since both satellites use global beams there is practically no antenna discrimination between wanted and unwanted signals at the satellite, and that this constitutes a worst case.

2 Input data

The values of the network parameters given in the table below are derived from those published in accordance with Appendix **4**.

	Symbol*	Value	Unit
Uplink at 6 175 MHz	P'_e	−37	dB(W/Hz)
	$G'_1(\theta_t)$	14.5	dB
	$G_2(\delta_{e'})$	15.5	dB
	L_u	200	dB
Downlink at 3 950 MHz	P'_s	−57	dB(W/Hz)
	$G'_3(\eta_e)$	−15.5	dB
	$G_4(\theta_t)$	14.5	dB
	L_d	196	dB
	10 log γ	15	dB
	T	105	K
	θ_t	5	degrees
* All capital symbols, except T, refer to parameters given in logarithmic units.			

3 Calculation of $\frac{\Delta T}{T}$

From equation (1)

$$10 \log \Delta T_s = P'_e + G'_1(\theta_t) + G_2(\delta_{e'}) + 228.6 - L_u$$
$$= -37 + 14.5 + 15.5 + 228.6 - 200 = 21.6 \text{ dBK}$$

Therefore,

$$\Delta T_s = 145 \text{ K}$$

From equation (2)

$$10 \log \Delta T_e = P'_s + G'_3(\eta_e) + G_4(\theta_t) + 228.6 - L_d$$
$$= -57 + 15.5 + 14.5 + 228.6 - 196 = 5.6 \text{ dBK}$$

Therefore;

$$\Delta T_e = 3.6 \text{ K}$$

From equation (3)

$$\Delta T = \gamma \Delta T_s + \Delta T_e$$
$$= 0.032 \times 145 + 3.6 = 8.2 \text{ K}$$

Thus

~~$$\frac{\Delta T}{T} \times 100 = \frac{8.2 \times 100}{105} = 7.8$$ %~~

~~4 Conclusion~~

~~In the example shown, the percentage increase in equivalent satellite link noise temperature is 7.8%. Since it exceeds the threshold value of 6%, coordination between the two networks is required.~~

TBD

5/9.1.2/4.4.1.2 Option 1B

This option would propose no changes to RR Article **9**, including Nos. **9.7** and **9.41**, or RR Appendix **5**. Furthermore, in respect of RR Article **11**, changes are proposed only for 6/4 GHz and 10/11/12/14 GHz and only in respect of RR No. **11.32A** where the criterion is proposed changed from *C*/*I* to pfd levels. Furthermore, in changing from *C*/*I* to pfd levels, it is proposed to retain the interference thresholds at similar levels as today (i.e. the equivalent to $\Delta T/T = 6\%$). Also, examination of probability of harmful interference under RR No. **11.32A** for the other frequency bands would be as today, using *C*/*I* criteria as specified in a Rule of Procedure.

The pfd thresholds considered under this option require a certain level of homogeneity over the applications. If there are a large number of satellites operating close to each other, networks tend to adapt comparable technical parameters. Also, if the frequency band has been in use for a long period, applications and usage tend to become harmonized and technical characteristics such as TVRO antenna sizes and VSAT characteristics tend to stabilize and align with harmonized use.

The 6/4 GHz and 14/10/11/12 GHz frequency ranges have been in widespread use globally for several decades and there are a very large number of operational satellites in these frequency bands typically spaced about 2-3 degrees along the GSO arc. These frequency bands therefore are considered well suited for the introduction of pfd thresholds.

There are already a large number of submissions in the 30/20 GHz frequency range. However, in terms of practical networks in regular operation, the number is still relatively small. Moreover, the technical characteristics seen used in practical implementation varies a lot from network to network. For these reasons, it seems that for the time being it might be best to limit the introduction of pfd thresholds under RR No. **11.32A** to just the 6/4 GHz and 10/11/12/14 GHz frequency ranges.

Table 5/9.1.2/4-2 summarizes the changes introduced by this option compared to the current procedures.

TABLE 5/9.1.2/4-2

		Coordination stage		Application of RR No. **11.32A** at notification stage
		First step: Bureau identification of potentially affected administrations	Second step: possible application of RR No. **9.41**	
Current	Type of criterion	Coordination arc	$\Delta T/T$	*C/I*
	Criterion value	±8° in C band, ±7° in Ku-band, ±8° in Ka-band and above	$\Delta T/T > 6\%$	Part B, Section B3 of the RoP
Possible new criteria	Type of criterion	NOC	NOC	NOC / pfd levels (Note 2)
	Criterion value	TBD (Note 1)	NOC	NOC / pfd masks/thresholds (Note 3)

NOTE:

1 This option would apply to any size of the coordination arc, as today or any changes as may be decided by WRC-15 in respect of resolves 2 (see Section 5/9.1.2/4.2 above).

2 For all frequency bands except the 6/4 GHz and 10/11/12/14 GHz frequency ranges: NOC
For the 6/4 GHz and 10/11/12/14 GHz frequency ranges: Downlink pfd mask, uplink pfd level.

3 pfd masks and thresholds for 6/4 and 10/11/12/14 GHz bands.

For the 6/4 GHz and 10/11/12/14 GHz frequency bands*

Uplink pfd level	6 GHz	14 GHz	
pfd level ($dBW/m^2 \cdot Hz$)	−204.0	−208.0	($dBW/m^2 \cdot Hz$)

Downlink pfd masks

Downlink pfd mask at 4 GHz						
		θ	≤	0.09	−243.5	($dBW/m^2 \cdot Hz$)
0.09	<	θ	≤	3	$-243.5 + 20\log(\theta/0.09)$	($dBW/m^2 \cdot Hz$)
3	<	θ	≤	5.5	$-219.8 + 0.75 \cdot \theta^2$	($dBW/m^2 \cdot Hz$)
5.5	<	θ	≤	20.9	$-196.8 + 25\log(\theta/5.6)$	($dBW/m^2 \cdot Hz$)
20.9	<	θ			−182.6	($dBW/m^2 \cdot Hz$)
Downlink pfd mask at 10/11/12 GHz						
		θ	≤	0.05	−238.0	($dBW/m^2 \cdot Hz$)
0.05	<	θ	≤	3	$-238.0 + 20\log(\theta/0.05)$	($dBW/m^2 \cdot Hz$)
3	<	θ	≤	5	$-210.0 + 0.95 \cdot \theta^2$	($dBW/m^2 \cdot Hz$)
5	<	θ	≤	20.9	$-187.2 + 25\log(\theta/5)$	($dBW/m^2 \cdot Hz$)
20.9	<	θ			−171.9	($dBW/m^2 \cdot Hz$)

where θ denotes nominal geocentric separation (degrees) between interfering and interfered with satellite networks.

NOTE: FSS and BSS networks are also subject to other relevant limits of the RR, including RR Nos. **21.16** and **21.17**.

* The table below provides values of the parameters to determine the up- and downlink pfd thresholds under this option.

Downlink	**4 GHz**	**12 GHz**
Earth station antenna diameter	1.2-18 m	0.45-11 m
Earth station antenna diagram	Main lobe: According to Appendix 8, Section III Sidelobes: 29-25logθ dBi (Recommendation ITU-R BO.1213, which implements these main and sidelobe characteristics, was used for the calculations)	
Earth station noise temperature	95 K	125 K
Earth station antenna efficiency	70%	70%
Equivalent $\Delta T/T$	6%	6%
Uplink	**6 GHz**	**14 GHz**
Maximum satellite G/T	0 dB/K	11 dB/K
Equivalent $\Delta T/T$	6%	6%

EXAMPLE OF REGULATORY TEXT IN RESPECT OF OPTION 1B

NOC

ARTICLE 9

Procedure for effecting coordination with or obtaining agreement of other administrations[1, 2, 3, 4, 5, 6, 7, 8, 8*bis*] (WRC-12)

Reasons: No changes to the provisions of RR Article **9** in respect of Option 1B.

ARTICLE 11

Notification and recording of frequency assignments[1, 2, 3, 4, 5, 6, 7, 7*bis*] (WRC-12)

Section II − Examination of notices and recording of frequency assignments in the Master Register

MOD

11.32A *c)* with respect to the probability of harmful interference that may be caused to or by assignments recorded with a favourable finding under Nos. **11.36** and **11.37** or **11.38**, or recorded in application of No. **11.41**, or published under Nos. **9.38** or **9.58** but not yet notified, as appropriate, for those cases for which the notifying administration states that the procedure for coordination under Nos. **9.7**, **9.7A**, **9.7B**, **9.11**, **9.12**, **9.12A**, **9.13** or **9.14**, could not be successfully completed (see also No. **9.65**);[14, 14bis] or (WRC-2000)

NOC

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[14] **11.32A.1**

ADD

[14*bis*] **11.32A.2** The criteria to determine the probability of harmful interference and the criteria for the formulation of the findings of the Bureau in respect of assignments in the frequency bands identified in 1) and 2) in Table **5-1** of Appendix **5** of these regulations are contained in Resolution **[1B912] (WRC-15)**. (WRC-15)

APPENDIX 5 (REV.WRC-12)

Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9

NOC

TABLE 5-1 (Rev.WRC-12)

Technical conditions for coordination
(see Article **9**)

NOTE: Depending upon decisions of WRC-15 in respect of *resolves* 2 of Resolution **756 (WRC-12)**, the numerical values for the size of the coordination arc in one or more of the listed frequency bands of Table 5-1 may change. This option is neutral in respect of the size of the coordination arc and decisions on the size of the coordination arc will not lead to a need for consequential changes in respect of this option or vice-versa.

ADD

RESOLUTION [1B912] (WRC-15)

Application of pfd criteria to assess the potential for harmful interference under No. 11.32A for fixed-satellite and broadcasting-satellite service networks in the 4/6 GHz and 10/11/12/14 GHz bands not subject to a Plan

The World Radiocommunication Conference (Geneva, 2015),

considering

a) that the 4/6 GHz and 10/11/12/14 GHz frequency ranges, not subject to a Plan, are extensively used with operational satellites about every 2-3° around the geostationary arc;

b) that there currently are a very large number of satellite networks submitted to ITU-R for these frequency bands;

c) that these above factors have led to significant difficulties for administrations to introduce new satellite networks;

d) that more precise criteria to assess the probability of harmful interference under No. **11.32A** have the potential to reduce undue protection requirements for assignments in respect of incoming assignments;

e) that reduction of undue protection requirements will facilitate coordination of submissions of new networks;

f) that due to the congestion in these frequency bands and due to the maturity of the technology and applications in these frequency bands, practical satellite implementations are seen to in practice use relatively homogeneous technical parameters;

g) that use of more homogeneous technical parameters will facilitate efficient spectrum usage and support introduction of new networks;

h) that the use of pfd thresholds will encourage use of more homogeneous technical parameters and support efficient spectrum usage,

resolves

1 that in the frequency band 3 400-4 200 MHz (space-to-Earth), assignments for a fixed-satellite service (FSS) space station with respect to other FSS networks do not have the potential to cause harmful interference if the pfd produced under assumed free space propagation conditions, does not exceed the threshold values shown below, anywhere within the service area of the potentially affected assignment:

		θ	$\leq$	0.09°	-243.5	(dBW/m^2 · Hz)
0.09°	<	θ	$\leq$	3°	$-243.5 + 20\log(\theta/0.09)$	(dBW/m^2 · Hz)
3°	<	θ	$\leq$	5.5°	$-219.8 + 0.75 \cdot \theta^2$	(dBW/m^2 · Hz)
5.5°	<	θ	$\leq$	20.9°	$-196.8 + 25\log(\theta/5.6)$	(dBW/m^2 · Hz)
20.9°	<	θ			-182.6	(dBW/m^2 · Hz)

where θ is the minimum nominal geocentric orbital separation, in degrees, between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies;

2 that in the frequency bands 5 725-5 850 MHz (Region 1), 5 850-6 725 MHz and 7 025-7 075 MHz (Earth-to-space), assignments for an FSS earth station with respect to other FSS networks do not have the potential to cause harmful interference if the pfd produced at the geostationary orbit location of the other FSS network under assumed free-space propagation conditions, does not exceed -204.0 dBW/m^2 · Hz, taking into account the respective East-West station-keeping accuracies;

3 that in the frequency bands 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz (Region 2), 12.2-12.5 GHz (Region 3), 12.5-12.7 GHz (Regions 1 and 3) and 12.7-12.75 GHz (space-to-Earth), assignments for a FSS or broadcasting-satellite service (BSS) space station with respect to other FSS or BSS networks do not have the potential to cause harmful interference if the pfd produced under assumed free-space propagation conditions, does not exceed the threshold values shown below, anywhere within the service area of the potentially affected assignment:

		θ	$\leq$	0.05°	-238.0	(dBW/m^2 · Hz)
0.05°	<	θ	$\leq$	3°	$-238.0 + 20\log(\theta/0.05)$	(dBW/m^2 · Hz)
3°	<	θ	$\leq$	5°	$-210.0 + 0.95 \cdot \theta^2$	(dBW/m^2 · Hz)
5°	<	θ	$\leq$	20.9°	$-187.2 + 25\log(\theta/5)$	(dBW/m^2 · Hz)
20.9°	<	θ			-171.9	(dBW/m^2 · Hz)

where θ is the minimum nominal geocentric orbital separation, in degrees, between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies;

4 that in the frequency band 13.75-14.5 GHz (Earth-to-space), assignments for an FSS earth station with respect to other FSS networks do not have the potential to cause harmful interference if the pfd produced at the geostationary orbit location of the other FSS network under assumed free-space propagation conditions, does not exceed -208 dBW/m^2 · Hz, taking into account the respective East-West station-keeping accuracies;

5 that when the Bureau, under No. **11.32A**, conducts its examination of the probability of harmful interference in accordance with this Resolution, the above criteria shall be used.

NOTE: FSS and BSS networks are also subject to other relevant limits of the RR, including, but limited to, Nos. **21.16** and **21.17**.

5/9.1.2/4.4.1.5 Option 1C

This option is similar to Option 1B described in section 5/9.1.2/4.4.1.2, but proposes to apply pfd thresholds for the 6/4 GHz and 10/11/12/14 GHz bands only in respect of satellite networks outside the coordination arc.

Table 5/9.1.2/4-3 summarizes the changes introduced by this option compared to the current procedures.

TABLE 5/9.1.2/4-3

		Coordination stage		Application of RR No. **11.32A** at notification stage
		First step: Bureau identification of potentially affected administrations	Second step: possible application of RR No. **9.41**	
Current	Type of criterion	Coordination arc	$\Delta T/T$	*C/I*
	Criterion value	±8° in C band, ±7° in Ku-band, ±8° in Ka-band and above	$\Delta T/T > 6\%$	Part B, Section B3 of the RoP
Possible new	Type of criterion	NOC	NOC	NOC / pfd levels (Note 2)

criteria	Criterion value	TBD (Note 1)	NOC	NOC / pfd masks/thresholds (Note 3)

Notes:

1 This option would apply to any size of the coordination arc, as today or any changes as may be decided by WRC-15 in respect of *resolves* 2.

2 For all frequency bands except the 6/4 GHz and 10/11/12/14 GHz frequency ranges: NOC

For the 6/4 GHz and 10/11/12/14 GHz frequency ranges in respect of satellite networks inside the coordination arc: NOC

For the 6/4 GHz and 10/11/12/14 GHz frequency ranges in respect of satellite networks outside the coordination arc: Downlink pfd mask, uplink pfd thresholds.

3 pfd masks and thresholds for 6/4 and 10/11/12/14 GHz bands:

For the 6/4 GHz and 10/11/12/14 GHz frequency bands**

Uplink pfd level	6 GHz	14 GHz	
pfd level (dBW/m^2 · Hz)	−204.0***	−208.0***	(dBW/m^2 · Hz)

Downlink pfd masks

Downlink pfd mask at 4 GHz						
8*	≤	θ	≤	20.9	−196.8*** + 25log(θ/5.6)	(dBW/m^2 · Hz)
20.9	<	θ			−182.6***	(dBW/m^2 · Hz)
Downlink pfd mask at 10/11/12 GHz						
7*	≤	θ	≤	20.9	−187.2*** + 25log(θ/5)	(dBW/m^2 · Hz)
20.9	<	θ			−171.9***	(dBW/m^2 · Hz)

where θ denotes nominal geocentric separation (degrees) between interfering and interfered with satellite networks.

* *NOTE: These are the current values of the coordination arc. Depending on decisions of WRC-15, the size of the coordination arc may change and these values should be adjusted accordingly.*

NOTE: FSS and BSS networks are also subject to other relevant limits of the RR, including RR Nos. ***21.16*** *and* ***21.17****.*

**The table below provides values of the parameters to determine the up- and downlink pfd thresholds under this option.

Downlink	**4 GHz**	**12 GHz**
Earth station antenna diameter	1.2-18 m	0.45-11 m
Earth station antenna diagram	Main lobe: According to Appendix 8, Section III Sidelobes: 29-25logθ dBi (Recommendation ITU-R BO.1213, which implements these main and sidelobe characteristics, was used for the calculations)	
Earth station noise temperature	95 K	125 K
Earth station antenna efficiency	70%	70%
Equivalent Δ*T*/*T*	6%	6%
Uplink	**6 GHz**	**14 GHz**

Maximum satellite G/T	0 dB/K	11 dB/K
Equivalent $\Delta T/T$	6%	6%

***NOTE: These numerical values are based upon an interference level to trigger coordination equivalent to $\Delta T/T$ = 6% for the 6/4 GHz and 10/11/12/14 GHz frequency ranges. If different levels of interference are determined as the triggering level, these levels should be adjusted as follows:

$$\text{New value } (\Delta T/T = Y\%) = \text{Above value } (\Delta T/T = 6\%) + 10 \cdot \log(Y/6)$$

EXAMPLE OF REGULATORY TEXT IN RESPECT OF OPTION 1C

NOC

ARTICLE 9

Procedure for effecting coordination with or obtaining agreement of other administrations[1, 2, 3, 4, 5, 6, 7, 8, 8*bis*] (WRC-12)

Reasons: No changes to the provisions of RR Article **9** in respect of Option 1C.

ARTICLE 11

Notification and recording of frequency assignments[1, 2, 3, 4, 5, 6, 7, 7*bis*] (WRC-12)

Section II − Examination of notices and recording of frequency assignments in the Master Register

MOD

11.32A *c)* with respect to the probability of harmful interference that may be caused to or by assignments recorded with a favourable finding under Nos. **11.36** and **11.37** or **11.38**, or recorded in application of No. **11.41**, or published under Nos. **9.38** or **9.58** but not yet notified, as appropriate, for those cases for which the notifying administration states that the procedure for coordination under Nos. **9.7**, **9.7A**, **9.7B**, **9.11**, **9.12**, **9.12A**, **9.13** or **9.14**, could not be successfully completed (see also No. **9.65**);[14, 14*bis*] or (WRC-2000)

NOC

_____

[14] **11.32A.1**

ADD

_____

[14*bis*] **11.32A.2** The criteria to determine the probability of harmful interference and the criteria for the formulation of the findings of the Bureau in respect of assignments in the frequency bands identified in 1) and 2) in Table **5-1** of Appendix **5** of these regulations for satellite networks having a nominal orbit separation in the geostationary arc of 8* and 7* degrees respectively are contained in Resolution **[1C912] (WRC-15)**. (WRC-15)

** NOTE: These are the current values of the coordination arc. Depending on decisions of WRC-15, the size of the coordination arc may change and these values should be adjusted accordingly.*

MOD

APPENDIX 5 (REV.WRC-~~12~~15)

Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9

MOD

TABLE 5-1 (REV.WRC-~~12~~15)

Technical conditions for coordination
(see Article **9**)

...

*NOTE: Depending upon decisions of WRC-15 in respect of resolves 2 of Resolution **756 (WRC-12)**, the numerical values for the size of the coordination arc in one or more of the listed frequency bands of Table 5-1 may change. This option is neutral in respect of the size of the coordination arc and decisions on this option will have no implications on the decisions in respect of the size of the coordination arc. However, should WRC-15 decide to change the size of the coordination arc, the lower orbit separation limit of the pfd masks would need to be amended accordingly.*

*This option is also neutral in respect of the value of the ΔT/T to be included in the coordination under RR No. **9.41**, as specified in Table **5-1**. However, should WRC-15 decide to make changes to this value, it might be appropriate to consider changes also to the interference levels used in the examination under RR No. **11.32A**, including those in Resolution **[1C912] (WRC-15)** below.*

ADD

RESOLUTION [1C912] (WRC-15)

Application of pfd criteria to assess the potential for harmful interference under No. 11.32A for fixed-satellite and broadcasting-satellite service networks in the 4/6 GHz and 10/11/12/14 GHz bands not subject to a Plan

The World Radiocommunication Conference (Geneva, 2015),

considering

a) that the 4/6 GHz and 10/11/12/14 GHz frequency ranges, not subject to a Plan, are extensively used with operational satellites about every 2-3° around the geostationary arc;

b) that there currently are a very large number of satellite networks submitted to ITU-R for these frequency bands;

c) that these above factors have led to significant difficulties for administrations to introduce new satellite networks;

d) that more precise criteria to assess the probability of harmful interference under No. **11.32A** have the potential to reduce undue protection requirements for assignments in respect of incoming assignments;

e) that reduction of undue protection requirements will facilitate coordination of submissions of new networks;

f) that due to the congestion in these frequency bands and due to the maturity of the technology and applications in these frequency bands, practical satellite implementations are seen in practice to use relatively homogeneous technical parameters;

g) that use of more homogeneous technical parameters will facilitate efficient spectrum usage and support introduction of new networks;

h) that the use of pfd thresholds will encourage use of more homogeneous technical parameters and support efficient spectrum usage,

resolves

1 that for satellite networks operating in the frequency bands 3 400-4 200 MHz (space-to-Earth) and 5 725-5 850 MHz (Region 1), 5 850-6 725 MHz and 7 025-7 075 MHz (Earth-to-space) having a nominal geocentric separation in the geostationary arc of 8* degrees or more, assignments for a fixed-satellite service (FSS) satellite network with respect to other FSS networks do not have the potential to cause harmful interference if:

a) the pfd produced under assumed free-space propagation conditions, does not exceed the threshold values shown below, anywhere within the service area of the potentially affected assignment:

$$8^{*\circ} \leq \theta \leq 20.9^\circ \qquad -196.8 + 25\log(\theta/5.6) \quad (\text{dBW/m}^2 \cdot \text{Hz})$$

$$20.9^\circ < \theta \qquad -182.6 \quad (\text{dBW/m}^2 \cdot \text{Hz})$$

where θ is the minimum nominal geocentric orbital separation, in degrees, between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies;

b) the pfd produced at the geostationary orbit location of the other FSS network under assumed free space propagation conditions, does not exceed -204.0 dBW/m^2 · Hz, taking into account the respective East-West station-keeping accuracies;

2 that in the frequency bands 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz (Region 2), 12.2-12.5 GHz (Region 3), 12.5-12.7 GHz (Regions 1 and 3) and 12.7-12.75 GHz (space-to-Earth) and 13.75-14.5 GHz (Earth-to-space), assignments for an FSS or broadcasting-satellite service (BSS) satellite network with respect to other FSS or BSS networks having a nominal geocentric separation in the geostationary arc of 7* degrees or more do not have the potential to cause harmful interference if:

a) the pfd produced under assumed free-space propagation conditions, does not exceed the threshold values shown below, anywhere within the service area of the potentially affected assignment:

7*°	≤	θ	≤	20.9°	$-187.2 + 25\log(\theta/5)$ (dBW/m^2 · Hz)
20.9°	<	θ			-171.9 (dBW/m^2 · Hz)

where θ is the minimum nominal geocentric orbital separation, in degrees, between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies;

b) the pfd produced at the geostationary orbit location of the other FSS network under assumed free-space propagation conditions, does not exceed −208.0 dBW/m^2 · Hz, taking into account the respective East-West station-keeping accuracies;

3 that when the Bureau, under No. **11.32A**, conducts its examination of the probability of harmful interference in accordance with this Resolution, the above criteria shall be used.**

*NOTE: FSS and BSS networks are also subject to other relevant limits of the RR, including, but not limited to, RR Nos. **21.16** and **21.17**.*

** NOTE: These are the current values of the coordination arc. Depending on decisions of WRC-15, the size of the coordination arc may change and these values should be adjusted accordingly.*

*** NOTE: With the adoption of this Resolution by a WRC, it is understood that RRB in updating their RoPs would amend the RoP for **11.32A** accordingly.*

5/9.1.2/4.4.1.4 Option 1D

No changes to the RR.

5/9.1.2/4.4.1.5 Regulatory solutions in respect of procedure of transition to new criterion

This Resolution may apply to Option 1A above.

ADD

RESOLUTION [A912] (WRC-15)

Procedure and time-frame for the transition to the new criterion of permissible single-entry interference established by WRC-15

The World Radiocommunication Conference (Geneva, 2015),

considering

a) that WRC-15 adopted the new criterion of frequency sharing and method of calculation which description is included in Appendix **8 (Rev.WRC-15)** or which is referred to;

b) that the frequency-sharing condition is the permissible single-entry interference satisfying $C/I \geq C/N + X$ (dB)*,

* 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T$ = 20%, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%} = 7.0 - 10\log(Y/20)$.

considering further

a) the significant congestion of geostationary orbit by submitted and brought into use networks in the unplanned 4/6 GHz and 10/11/12/14 GHz bands, where average orbital separation between operational GSO satellites is currently 2-3 degrees;

b) complexity and incompleteness of the coordination process leading to a large number of No. **11.41** applications;

c) the need for simplification of the coordination process to facilitate access to GSO orbital-spectrum resource for new satellite networks;

d) that administrations to be coordinated with and frequency assignments to be taken into account in effecting coordination are defined using Appendix **5**,

recognizing

a) that in view of changing permissible single-entry interference criterion, the BR requires instructions from the Conference in respect of processing of notices;

b) that it is necessary to establish procedure and time-frame for transition to the new criterion of permissible single-entry interference for the following categories of satellite network notices:

– submitted for advance publication of information or for coordination after closing date of WRC-15;

– received under No. **9.6** but not processed yet by the Bureau before "Date";

– being at different stages of coordination/notification or recording;

– frequency assignments already notified and recorded in MIFR;

c) that, before WRC-15, the criterion $\Delta T/T = 6\%$ was used in determining frequency assignments to be taken into account under No. **9.7** or at the stage of applying No. **9.27** depending on applicability of coordination arc criterion and/or in applying No. **9.41**;

d) that WRC-15 established that the cases when *C*/*I* calculated value is less than the established criterion *C*/*N* + X* (dB) (see Appendices **5** and **8**) are the conditions for coordination,

resolves

1 that from xx xxx 201(5) in determining necessity of coordination between assignments to satellite networks under No. **9.7**, as well as applying Nos. **9.41** and **11.32A**, criterion *C*/*I* shall be used, which is determined on the basis of permissible single-entry interference criterion *C*/*N* + X (dB)[1];

2 that from xx xxx 201(5) the established permissible single-entry interference criterion shall be applied:

– to all submissions of satellite networks under No. **9.1**, received by the BR after closing WRC-15, in respect of submissions sent to the BR under Article **9** after closing date of WRC-15;

---

[1] This criterion of single-entry interference corresponds to $\Delta T/T$ = Y*%.

* 7.0 dB ≤ X ≤ 12.2 dB. For an interference level equivalent to $\Delta T/T = 20\%$, X = 7.0 dB. If other levels of interference are to be considered, X may be adjusted by $X_{Y\%} = 7.0 - 10\log(Y/20)$.

– to all submissions of satellite networks under No. **9.1**, received by the BR before WRC-15 but have not sent submissions yet under No. **9.6**, in respect of submissions sent to the BR under Article **9** after closing date of WRC-15;

– to all submissions of satellite networks, coordination request for which the BR received after closing date of WRC-15 in respect of submissions sent to the BR under Article **9** after closing date of WRC-15;

– to all submissions received by the BR not listed above, the criterion value existing before closing date of WRC-15 shall continue to be applied,

resolves further

to recommend to the BR timely (in [2] months after closing date of WRC-15) to refine the available software and provide it to the administrations for:

– *C*/*I* ratio calculation;

– *C*/*N* ratio calculation using parameters submitted under Appendix **4**, and inclusion of the information into notification database.

5/9.1.2/4.4.2 Regulatory and procedural considerations in respect of *resolves* 2

Currently, coordination triggers such as the coordination arc are used to identify administrations with which coordination is to be effected and the associated satellite networks to be considered.

In certain frequency bands allocated to the FSS, where the coordination arc applies, a new satellite network will likely be required to effect coordination with a large number of existing and proposed satellite networks, with an orbital separation less than the associated coordination arc. Studies conducted by ITU-R have demonstrated that a reduction to the coordination arc may be possible while concurrently ensuring adequate protection to other existing and proposed satellite networks. If the coordination arc values are selected such that they more accurately reflect the operational satellite environment, this might also have the effect of reducing the need for provisional recording under RR No. **11.41**.

5/9.1.2/4.4.2.1 Option 2A

– In the frequency bands under item 1) of Table 5-1 of RR Appendix **5**, reduce the coordination arc from ±8º to ±6º;

– In the frequency bands under item 2) of Table 5-1 of RR Appendix **5** , reduce the coordination arc from ±7º to ±5º;

– In the frequency bands under the other items of Table 5-1 of RR Appendix **5**, no change to the current coordination arc.

The further reduction of the size of the coordination arc requires a certain level of homogeneity over the applications. If there are a large number of satellites operating close to each other, networks tend to adapt comparable technical parameters. Also, if the frequency band has been in use for a long period, applications and usage tend to become harmonized and technical characteristics such as TVRO antenna sizes and VSAT characteristics tend to stabilize and align with harmonized use.

As opposed to the 30/20 GHz frequency range, the 6/4 GHz and 14/10/11/12 GHz frequency ranges have been in widespread use globally for several decades and there are a very large number of operational satellites in these frequency ranges typically spaced about 2-3 degrees along the GSO arc. Therefore, the 6/4 GHz and 14/10/11/12 GHz frequency ranges are considered well suited for a reduction of the size of the coordination arc, but not the 30/20 GHz frequency range. As

applications and technical characteristics in the 30/20 GHz frequency range develop, the appropriate size of the coordination arc could be further studied.

Any administration, not identified by the Bureau under RR No. **9.36**, having satellite networks outside the coordination arcs can still be included in the coordination process through the application of RR No. **9.41**.

This option can be implemented by modifying the FSS coordination arc values for the 6/4 GHz and 14/10/11/12 GHz frequency ranges in Table 5-1 of RR Appendix **5**. An example of regulatory text is shown below.

APPENDIX 5 (REV.WRC-12)

Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9

MOD

TABLE 5-1 (REV.WRC-~~12~~15)

Technical conditions for coordination
(see Article **9**)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO	A station in a satellite network using the geostationary-satellite orbit (GSO), in any space radiocommunication service, in a frequency band and in a Region where this service is not subject to a Plan, in respect of any other satellite network using that orbit, in any space radiocommunication service in a frequency band and in a Region where this service is not subject to a Plan, with the exception of the coordination between earth stations operating in the opposite direction of transmission	1) 3 400-4 200 MHz 5 725-5 850 MHz (Region 1) and 5 850-6 725 MHz 7 025-7 075 MHz 2) 10.95-11.2 GHz 11.45-11.7 GHz 11.7-12.2 GHz (Region 2) 12.2-12.5 GHz (Region 3) 12.5-12.75 GHz (Regions 1 and 3) 12.7-12.75 GHz (Region 2) and 13.75-14.5 GHz	i) Bandwidth overlap, and ii) any network in the fixed-satellite service (FSS) and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~8~~6° of the nominal orbital position of a proposed network in the FSS i) Bandwidth overlap, and ii) any network in the FSS or broadcasting-satellite service (BSS), not subject to a Plan, and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~7~~5° of the nominal orbital position of a proposed network in the FSS or BSS, not subject to a Plan		With respect to the space services listed in the threshold/condition column in the bands in 1), 2), 3), 4), 5), 6), 7) and 8), an administration may request, pursuant to No. **9.41**, to be included in requests for coordination, indicating the networks for which the value of $\Delta T/T$ calculated by the method in § 2.2.1.2 and 3.2 of Appendix **8** exceeds 6%. When the Bureau, on request by an affected administration, studies this information pursuant to No. **9.42**, the calculation method given in § 2.2.1.2 and 3.2 of Appendix **8** shall be used

5/9.1.2/4.4.2.2 Option 2B

- In the frequency bands under item 1) of Table 5-1 of RR Appendix **5**, reduce the coordination arc from ±8º to ±6º;
- In the frequency bands under item 2) of Table 5-1 of RR Appendix **5**, reduce the coordination arc from ±7º to ±5º;
- In the frequency bands under items 3) and 7) of Table 5-1 of RR Appendix **5**, reduce the coordination arc from ±8º to ±6º;
- In the frequency bands under items 4), 5), 6) and 8) of Table 5-1 of RR Appendix **5**, no change.

Any administration, not identified by the Bureau under RR No. **9.36**, having satellite networks outside the coordination arcs can still be included in the coordination process through the application of RR No. **9.41**.

This option can be implemented by modifying Table 5-1 of RR Appendix **5**. An example of regulatory text is shown below.

APPENDIX 5 (REV.WRC-12)

Identification of administrations with which coordination is to be effected or agreement sought under the provisions of Article 9

MOD

TABLE 5-1 (REV.WRC-~~12~~15)

Technical conditions for coordination
(see Article **9**)

Reference of Article 9	**Case**	**Frequency bands (and Region) of the service for which coordination is sought**	**Threshold/condition**	**Calculation method**	**Remarks**
No. **9.7** GSO/GSO	A station in a satellite network using the geostationary-satellite orbit (GSO), in any space radiocommunication service, in a frequency band and in a Region where this service is not subject to a Plan, in respect of any other satellite network using that orbit, in any space radiocommunication service in a frequency band and in a Region where this service is not subject to a Plan, with the exception of the coordination between earth stations operating in the opposite direction of transmission	1) 3 400-4 200 MHz 5 725-5 850 MHz (Region 1) and 5 850-6 725 MHz 7 025-7 075 MHz 2) 10.95-11.2 GHz 11.45-11.7 GHz 11.7-12.2 GHz (Region 2) 12.2-12.5 GHz (Region 3) 12.5-12.75 GHz (Regions 1 and 3) 12.7-12.75 GHz (Region 2) and 13.75-14.5 GHz	i) Bandwidth overlap, and ii) any network in the fixed-satellite service (FSS) and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~8~~6° of the nominal orbital position of a proposed network in the FSS i) Bandwidth overlap, and ii) any network in the FSS or broadcasting-satellite service (BSS), not subject to a Plan, and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~7~~5° of the nominal orbital position of a proposed network in the FSS or BSS, not subject to a Plan		With respect to the space services listed in the threshold/condition column in the bands in 1), 2), 3), 4), 5), 6), 7) and 8), an administration may request, pursuant to No. **9.41**, to be included in requests for coordination, indicating the networks for which the value of $\Delta T/T$ calculated by the method in § 2.2.1.2 and 3.2 of Appendix **8** exceeds 6%. When the Bureau, on request by an affected administration, studies this information pursuant to No. **9.42**, the calculation method given in § 2.2.1.2 and 3.2 of Appendix **8** shall be used

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		3) 17.7-20.2 GHz, (Regions 2 and 3), 17.3-20.2 GHz (Region 1) and 27.5-30 GHz	i) Bandwidth overlap, and ii) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~8~~6° of the nominal orbital position of a proposed network in the FSS		
		4) 17.3-17.7 GHz (Regions 1 and 2)	i) Bandwidth overlap, and ii) a) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the BSS, or b) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS		

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		5) 17.7-17.8 GHz	i) Bandwidth overlap, and ii) a) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the BSS, or b) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS NOTE – No. **5.517** applies in Region 2.		
		6) 18.0-18.3 GHz (Region 2) 18.1-18.4 GHz (Regions 1 and 3)	i) Bandwidth overlap, and ii) any network in the FSS or meteorological-satellite service and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±8° of the nominal orbital position of a proposed network in the FSS or the meteorological-satellite service		

TABLE 5-1 (*continued*) (REV.WRC-~~12~~15)

Reference of Article 9	Case	Frequency bands (and Region) of the service for which coordination is sought	Threshold/condition	Calculation method	Remarks
No. **9.7** GSO/GSO (*cont.*)		6*bis*) 21.4-22 GHz (Regions 1 and 3)	i) Bandwidth overlap; and ii) any network in the BSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±12° of the nominal orbital position of a proposed network in the BSS (see also Resolutions **554 (WRC-12)** and **553 (WRC-12)**).		No. **9.41** does not apply.
		7) Bands above 17.3 GHz, except those defined in § 3) and 6)	i) Bandwidth overlap, and ii) any network in the FSS and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±~~8~~6° of the nominal orbital position of a proposed network in the FSS (see also Resolution **901 (Rev.WRC-07)**)		
		8) Bands above 17.3 GHz except those defined in § 4), 5) and 6*bis*)	i) Bandwidth overlap, and ii) any network in the FSS or BSS, not subject to a Plan, and any associated space operation functions (see No. **1.23**) with a space station within an orbital arc of ±16° of the nominal orbital position of a proposed network in the FSS or BSS, not subject to a Plan, except in the case of a network in the FSS with respect to a network in the FSS (see also Resolution **901 (Rev.WRC-07)**)		

5/9.1.2/4.4.2.3 Option 2C

No changes to the RR.