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| PLENARY MEETING | | **Addendum 10 to Document 99(Add.22)-E** | |
|  | | **27 October 2023** | |
|  | | **Original: English** | |
|  | | | |
| Japan | | | |
| PROPOSALS FOR THE WORK OF THE CONFERENCE | | | |
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| Agenda item 7(H) | | | |

7 to consider possible changes, in response to Resolution 86 (Rev. Marrakesh, 2002) of the Plenipotentiary Conference, on advance publication, coordination, notification and recording procedures for frequency assignments pertaining to satellite networks, in accordance with Resolution **86** **(Rev.WRC‑07)**, in order to facilitate the rational, efficient and economical use of radio frequencies and any associated orbits, including the geostationary-satellite orbit;

7(H) Topic H - Enhanced protection of RR Appendices **30/30A** in Regions 1 and 3 and RR Appendix **30B**

Consideration on Topic H of WRC‑23 agenda item 7 regarding RR Appendix 30

# 1 Background

The scope of Topic H under WRC‑23 agenda item 7 is limited to (cited from section 4/7/8.1 of the CPM Report, Doc. [WRC‑23/3](https://www.itu.int/md/R23-WRC23-C-0003/en));

1 reviewing the possible removal of the provisions associated with implicit agreement in Regions 1 and 3 RR Appendices **30**/**30A** and RR Appendix **30B**, where appropriate;

2 consideration of applying a degradation tolerance of 0.25 dB in terms of EPM degradation for assignments in the Regions 1 and 3 Appendices **30**/**30A** Plan, as opposed to the current trigger of 0.45 dB.

The Working Party (WP) 4A meeting in May 2022 considered the subjects of implicit agreement in RR AP**30**/**30A**, **30B** and the EPM (equivalent protection margin) degradation tolerance in RR AP**30**/**30A** and decided to make these items to be a topic of WRC‑23 agenda item 7. Regarding the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB, Japan submitted a contribution (Doc. [4A/545](https://www.itu.int/md/R19-WP4A-C-0545/en)) proposing to retain the EPM degradation tolerance to be 0.45 dB.

Japan also proposed to the WP 4A meeting in September 2022 that in order to prevent the Plan assignment suffering a very low EPM and becoming useless it is effective to revise the provisions of implicit agreement, but the situation can’t be avoided by the reduction of the EPM degradation tolerance (Doc. [4A/714](https://www.itu.int/md/R19-WP4A-C-0714/en)).

It was pointed out during CPM23-2 meeting in March/April 2023 relating to Topic H of WRC‑23 agenda item 7 that further study is needed for the orbital separation ranges from 0 degrees to 9 degrees and level of frequency overlap ranges from partial to full overlap. Japan provided the results of the investigations for the applicability and effectiveness of pfd and EPM criteria taking into account the above aspects and proposed to revise Report [ITU‑R BO.2497-0](https://www.itu.int/pub/R-REP-BO.2497) (Doc. [4A/978](https://www.itu.int/md/R19-WP4A-C-0978/en), [Annex 1](https://www.itu.int/dms_ties/itu-r/md/19/wp4a/c/R19-WP4A-C-0978!N01!MSW-E.docx)).

This document provides the technical details on Topic H of WRC‑23 agenda item 7, which support the conclusion that in order to prevent the Plan assignment suffering a very low EPM and becoming useless it is effective to revise the provisions of implicit agreement, but the situation cannot be avoided by the reduction of the EPM degradation tolerance.

Section 4/7/8.3.2 on EPM degradation tolerance in RR Appendices **30**/**30A** in Regions 1 and 3 of Document WRC‑23/3 says as follows:

*With regard to the EPM degradation tolerances below are the views expressed:*

***View 1***

*It is recalled that the value of 0.45 dB was merely used to facilitate the revision of the Regions 1 and 3 Plan by WRC-2000. Now that the Regions 1 and 3 Plan has been revised, there is no need to increase the EPM degradation tolerance of 0.25 dB to 0.45 dB with respect of the BSS Plan Assignments or an assignment with national coverage. Furthermore, 0.25 dB overall EPM degradation tolerance is used in BSS Planned bands in Region 2.*

***View 2***

*Suggestions have been made on the reduction of the EPM (equivalent protection margin) degradation tolerance from its current 0.45 dB to 0.25 dB. Regarding such a possible reduction, a study made the following points and conclusions:*

*1) Historically, the EPM degradation tolerance was relaxed from 0.25 dB to 0.45 dB at WRC-2000. The reason for this relaxation was the adoption of digital modulation in the Regions 1 and 3 Plans which is more robust than analogue modulation. With the same reason, the protection ratio value for downlink co-channel signals was reduced to 21 dB from 23 dB (section 3.4 of Annex 5 to RR AP****30****), in addition to the relaxation of the EPM degradation tolerance.*

*2) Therefore, the modification of the EPM degradation tolerance, even if it applies to the Plan only, would create inconsistencies to the basis of the Plan in WRC‑2000 and sharing criterion, since the Plan from WRC-2000 is based on the EPM degradation tolerance of 0.45 dB.*

*3) There are two criteria for the sharing BSS frequency for Regions 1 and 3 in Annex 1 to RR Appendix****30****, EPM degradation tolerance and pfd masks (see Figure 4/7/8.3.2-1 for orbital separations of 3 deg. and 6 deg.). By reducing the EPM degradation tolerance from 0.45 dB (left side of Figure 4/7/8.3.2-1) to 0.25 dB (right side of Figure 4/7/8.3.2‑1), the allowable interference becomes stricter by about 3 dB if the* Ref. EPM *is already below 0 dB. However, around the* Ref. EPM *of 0 dB the pfd criterion is applicable since the allowable interference is less stringent than the EPM criterion. Therefore, the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB does not work in this area except for e.i.r.p. of 57 dBW, which corresponds to normal Plan assignments. However, for such a high e.i.r.p., if both interfering and interfered-with satellites suffered from low EPM, both satellites would severely interfere with each other. One of the causes of this large degradation, for example 10 dB degradation of EPM, is due to the provisions of the implicit agreement, even though the Plan assignments were recognized as significantly affected by the result of examination using EPM criterion or pfd criterion, and therefore the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB does not contribute to solve the problem for the Plan assignments.*

*It is worth mentioning that the phenomenon around the* Ref. EPM *of 0 dB, the pfd criterion is applicable when the allowable interference is less stringent than the EPM criterion. This view is drawn based on the two specific sharing scenarios of 3 and 6 degrees spacing and full frequency overlap. The phenomenon may not be applicable to other sharing scenarios between Plan assignments and additional uses noting that the orbital separation ranges from 0 degrees to 9 degrees and level of frequency overlap ranges from partial to full overlap. Therefore, further study is needed to verify whether the view that the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB does not contribute to solve the very low EPM problem for the Plan assignments is valid for other cases.*

*Figure 4/7/8.3.2-1*

*Application of EPM and pfd criteria*

|  |  |
| --- | --- |
| *(a) 3 deg spacing* | |
| *EPM degradation of −0.45 dB (Report ITU-R BO.2497)* | *EPM degradation of −0.25 dB* |
|  | |

|  |  |
| --- | --- |
| *(b) 6 deg spacing* | |
| *EPM degradation of −0.45 dB (Report ITU-R BO.2497)* | *EPM degradation of −0.25 dB* |
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*4) Calculation results on the mechanism of EPM degradation in BSS in Regions 1 and 3 showed that the cumulative EPM degradation resulted to be between −0.9 dB (−0.45 dB by one satellite network at +3 degrees and −0.45 dB by another satellite network at −3 deg.) and −2.7 dB depending on the surrounding beam shapes of six interfering satellite networks under the condition of the EPM degradation tolerance of 0.45 dB.*

This document provides more detailed information especially on View 2 (3) and (4) above.

# 2 Detailed information on View 2 of section 4/7/8.3.2 of Doc. WRC‑23/3

In the CPM-23 Report for Topic H of WRC‑23 agenda item 7 (Doc. WRC‑23/3), application of EPM and pfd criteria is given in Fig. 4/7/8.3.2-1 for the orbital separation angles of 3 and 6 degrees, and for the EPM degradation of −0.45 dB and −0.25 dB, respectively. The study for the other orbital separation angles of 0, 1 and 9 degrees are performed and the results are given in Fig. 1 as well as the results already exist in Fig. 4/7/8.3.2-1 of the CPM‑23 Report.

Note that in Fig. 1 the pfd hard limit line is outside of the figure for the orbital separation of 0 and 1 degrees. For the 9 degrees of orbital separation, the pfd hard limit and the pfd criteria is same. Then in this case the pfd criterion is always applied for all the *Ref. EPM*. Note also the difference in the threshold pfd values derived from EPM criterion between the allowable EPM degradation of −0.45 B and −0.25 dB is 2.7 dB when the *Ref. EPM* is equal to or less than 0 dB.

It can be said from Fig. 1 that in a range of *Ref. EPM* about from 0 dB to −5 dB, the pfd criterion is effective for low *Ce.i.r.p.*like 51.5 dBW and the orbital separation above 1 deg.. The pfd criterion is effective in this region to accommodate a newcomer if the existing satellites has a low *Ce.i.r.p..*

Figure 1

Application of EPM and pfd criteria

(Figure 4/7/8.3.2-1 in Doc. WRC‑23/3 is redrawn for orbital spacing of 3, 6 degrees)

|  |  |
| --- | --- |
| (a) 0 deg spacing | |
| EPM degradation of –0.45 dB | EPM degradation of –0.25 dB |
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|  |  |
| --- | --- |
| (b) 1 deg spacing | |
| EPM degradation of –0.45 dB (Report ITU-R BO.2497) | EPM degradation of –0.25 dB |
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|  |  |
| --- | --- |
| (c) 3 deg spacing  (Figure 4/7/8.3.2-1 in Doc. WRC-23/3 is redrawn) | |
| EPM degradation of –0.45 dB (Report ITU-R BO.2497) | EPM degradation of –0.25 dB |
|  | |

|  |  |
| --- | --- |
| (d) 6 deg spacing  (Figure 4/7/8.3.2-1 in Doc. WRC-23/3 is redrawn) | |
| EPM degradation of –0.45 dB (Report ITU-R BO.2497) | EPM degradation of –0.25 dB |
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|  |  |
| --- | --- |
| (e) 9 deg spacing | |
| EPM degradation of –0.45 dB | EPM degradation of –0.25 dB |
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For the orbital separation angle of 0 deg., the necessary geographical separation distances are calculated and shown in Table 1 for the allowable EPM degradation of −0.45 dB and −0.25 dB when the *Ref. EPM* equals to 0 dB. It is very difficult to share the same frequency at the same orbital position even though the EPM criterion is applied, since the necessary separation distances are 4 939 km and 6 719 km for the EPM degradation of −0.45 dB and −0.25 dB, respectively.

TABLE 1

Necessary geographical separation distances for the orbital separation angle of 0 deg., *Ce.i.r.p*. of 54.3 dBW, *Ref. EPM* of 0 dB

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| EPM degradation (dB) | BSS Plan pfd (dB(W/(m2 ･ MHz))) | Threshold pfd (dB(W/(m2 ･ MHz))) (Fig. 1) | Difference between the pfds  (dB) | Relative angle φ/φ0  (Fig. 2) | Beam width of antenna φ0  (deg.) | Separation angle φ  (deg.) | Separation distance *d*  (km) |
| −0.45 | −118 | −150 | 32 | 3.8 | 2 | 7.6 | 4 939 |
| −0.25 | −118 | −153 | 35 | 5.0 | 2 | 10 | 6 719 |

FIGURE 2

(Same as RR AP30 Annex 5)

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自動的に生成された説明

In the above discussion, the frequency is assumed to be fully overlapped. For the case of partial frequency overlapping, the threshold pfd values in Fig. 1 derived from the EPM criterion increase by an amount of overlapping frequency bandwidth. For the BSS Plan, bandwidth is 27 MHz, channel spacing between odd channel and even channel is 19.18 MHz. Here it is assumed the odd channel and even channel uses a same polarization. The *C/I* is calculated by taking into account the frequency overlapping (Recommendation ITU‑R BO.1293-2, Annex 1). The total overlapping frequency bandwidth with the upper and lower channels is 2 × (27-19.18) (MHz) (see Fig. 3). The threshold pfd value in Fig. 1 increases by 2.37 dB (= 10log(27/(2 × (27−19.18)))), when the interference comes from both upper and lower adjacent channels. Figure 4 shows the increase of 2.37 dB of the threshold pfd value in Fig. 1. Note that in this case the protection of interfered-with satellite network is unchanged to meet the EPM criterion.

FIGURE 3

Frequency overlapping with adjacent channels in BSS Plan

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中程度の精度で自動的に生成された説明

Figure 4

Application of EPM and pfd criteria for the partial frequency overlap (example)

|  |  |
| --- | --- |
| 3 deg spacing | |
| EPM degradation of –0.45 dB | EPM degradation of –0.25 dB |
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From the discussion mentioned above, the conclusion described in View 2 (3) in the CPM‑23 Report for Topic H of WRC‑23 agenda item 7 (Doc. WRC‑23/3) is valid for all orbital separations and the partial or full frequency overlap, that is:

*One of the causes of this large degradation, for example 10 dB degradation of EPM, is due to the provisions of the implicit agreement, even though the Plan assignments were recognized as significantly affected by the result of examination using EPM criterion or pfd criterion, and therefore the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB does not contribute to solve the problem for the Plan assignments.*

Regarding the conclusion described in View 2, 4) in the CPM‑23 Report for Topic H of WRC‑23 agenda item 7 (Doc. WRC‑23/3), it is shown in the Attachment 1 to this document that the cumulative EPM degradation results to be between −0.9 dB (−0.45 dB by Sat. 1 at +3 deg. and −0.45 dB by Sat. 4 at −3 deg.) and −2.7 dB depending on the surrounding beam shapes of 6 interfering satellites under the condition of the allowable EPM degradation of 0.45 dB.

# 3 Conclusion

It is shown that the revision of the provisions of implicit agreement is effective to solve the problem of large EPM degradation, but the reduction of the EPM degradation tolerance from 0.45 dB to 0.25 dB does not contribute to solve this problem.

ATTACHMENT 1

Calculation results on the mechanism of EPM degradation in BSS   
in Regions 1 and 3

# 1 Introduction

This attachment shows how much BSS assignments in Regions 1 and 3 degrade due to the interference from another BSS satellites. There are two frequency sharing criteria between BSS networks. In Section 1 of Annex 1 to Appendix **30** of the Radio Regulations (RR), two types of threshold value triggering coordination within a coordination arc of 9 degrees are given: a) pfd (power flux-density) and b) EPM (equivalent protection margin). According to the provision in RR as cited below, a proposed satellite network does not need to coordinate with others if either the pfd criterion or the EPM criterion is met within a coordination arc of 9 degrees.

*..., an administration in Region 1 or 3 is considered as not being affected if either of the following two conditions is met:*

*a) ..., the power flux-density at any test point within the service area..., does not exceed the following values: (WRC-15)*

*b) … the equivalent downlink protection margin corresponding to a test point of its assignment … does not fall more than 0.45 dB below 0 dB or, if already negative, more than 0.45 dB.*

In this attachment, the following 3 scenarios are considered with respect to the cumulative EPM degradation.

1 Scenario 1

Six circular beams emitted respectively from 6 interfering satellites are assumed to surround the desired service area and touch the neighbouring beams. The 6 satellites have a same e.i.r.p. and are arranged to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30**. The necessary satellite spacings are calculated.

2 Scenario 2

Six shaped beams, including fast roll-off circular beam, emitted respectively from 6 interfering satellites are assumed to surround the desired service area with some distance from the neighbouring beams. The 6 satellites are arranged apart from the desired satellite and having a small amount of orbital spacing each other. Then the necessary reduction of e.i.r.p. for the 6 satellites, i.e. necessary antenna discrimination, toward the neighbouring beams is calculated to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30**.

3 Scenario 3

The 6 shaped beams, including fast roll-off circular beam, emitted respectively from 6 interfering satellites are assumed to surround the desired service area with some distance from the neighbouring beams. The 6 satellites are arranged apart from each other with some orbital spacing each other. Then the necessary reduction of e.i.r.p. for the 6 satellites, i.e. necessary antenna discrimination, toward the neighbouring beams is calculated to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30**.

# 2 Example of Scenario 1

## 2.1 Input

Sat. 0: Desired satellite

Sat. 1, 2, 3, 4, 5, 6: Satellites interfering Sat. 0.

The beams of Sat. 0 – 6: see Fig. A2-1.

e.i.r.p.: Same value for all beams, e.g. 57 dBW/27 MHz.

Fast roll off antenna pattern: No. The e.i.r.p. at the touching point of beams is same, e.g., 57 dBW/27 MHz.

Figure A2-1

The beams of Sat. 0 – 6 for Scenario 1

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自動的に生成された説明

## 2.2 Output

The necessary satellite spacings to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30** as shown in Fig. A2-2.

Figure A2-2

The necessary satellite spacings

Chart

Description automatically generated

## 2.3 Method

i) At first Sat. 0 is assumed to have a *Ref. EPM* of 0 dB.

ii) Sat. 1 comes next to Sat. 0. In order to make the EPM degradation of Sat. 0 by 0.45 dB, Sat. 1 must be 8.36 deg. apart from Sat. 0. Note that in this case the EPM criterion is applied as shown in Table A2-1.

iii) Next Sat. 2 comes next to Sat. 1. In order to make the EPM degradation of Sat. 1 by more 0.45 dB, Sat. 2 must be 8.06 deg. apart from Sat. 1. Due to Sat. 2, the *Ref. EPM* of Sat. 0 becomes −0.53 dB. Note that the orbital spacing between Sat. 0 and Sat. 2 is 16.42 deg., then the EPM degradation is not taken into account in accordance AP**30**(9 deg. coordination arc), however, in this attachment the actual EPM degradation is calculated.

iv) Next Sat. 3 comes next to Sat. 2. In order to make the EPM degradation of Sat. 2 by more 0.45 dB, Sat. 2 must be 7.70 deg. apart from Sat. 2. Due to Sat. 3, the *Ref. EPM* of Sat. 0 becomes −0.57 dB.

v) Next Sat. 4 comes next to Sat. 0 in the opposite side of Sat. 1. In order to make the EPM degradation of Sat. 0 by more 0.45 dB, Sat. 4 must be 7.99 deg. apart from Sat. 0. Due to Sat. 4, the *Ref. EPM* of Sat. 0 becomes −1.02 dB.

vi) Sat. 5 and Sat. 6 come in a similar way of Sat. 2 and Sat. 3.

vii) Finally, the *Ref. EPM* of Sat. 0 becomes −1.14 dB with six interfering satellites.

viii) Another new satellites may be come but with reduced power and Sat. 0 suffers from less significant EPM.

Table A2-1

Necessary orbital separation to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix 30

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sat. | 0+1 | 0+1+2 | 0+1+2+3 | 0+4 | 0+4+5 | 0+4+5+6 |
| *Ce.i.r.p.* (dBW) | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 |
| *PR*(dB) | 21.00 | 21.00 | 21.00 | 21.00 | 21.00 | 21.00 |
| *C/Iaggr* (dB) | 21.00 | 20.55 | 20.10 | 20.43 | 19.98 | 19.53 |
| *Iaggr* (dBW) | 36.00 | 36.45 | 36.90 | 36.57 | 37.02 | 37.47 |
| *Ref. EPM* (dB) | **0.00** | **−0.45** | **−0.90** | **−0.57** | **−1.02** | **−1.47** |
| *C/Inew* (dB) | **30.61** | **30.17** | **29.72** | **30.09** | **29.57** | **29.12** |
| *Inew* (dBW) | 26.39 | 26.83 | 27.28 | 26.91 | 27.43 | 27.88 |
| *C*/(*Iaggr*+ *Inew*) (dB) | 20.55 | 20.10 | 19.65 | 19.98 | 19.53 | 19.08 |
| *EPM* (*Iaggr*+ *Inew*) (dB) | **−0.45** | **−0.90** | **−1.35** | **−1.02** | **−1.47** | **−1.92** |
| Degradation(dB) | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** |
| Off-axis angle (deg) | 9.20 | 8.87 | 8.47 | −8.79 | −8.39 | −8.02 |
| Orbital separation θ (deg) | **8.36** | **8.06** | **7.70** | **−7.99** | **−7.63** | **−7.29** |
| pfd by EPM criterion  (dB(W/(m2 · 27 MHz))) | −105.6 | −105.6 | −105.6 | −105.6 | −105.6 | −105.6 |
| Distance from Sat. (km) Δσ = 30 deg., *El*= 38 deg. | 37 934 | 37 934 | 37 934 | 37 934 | 37 934 | 37 934 |
| pfd at θ, AP**30** Annex 1 (dB(W/(m2 · 27 MHz))) | −106.1 | −106.5 | −107.0 | −106.6 | −107.1 | −107.6 |
| EPM or pfd | EPM | EPM | EPM | EPM | EPM | EPM |
| *C/Inew* (dB) gives EPM degradation of −0.45 dB.  Off-axis angle (deg) of Rec. ITU-R BO.1213 gives the discrimination corresponding to *C/Inew*.  Orbital separation (deg) = Off-axis angle / 1.1. | | | | | | |

Table A2-2

Necessary orbital separation to protect the adjacent satellite and new EPM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sat | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| EPM(dB) | 0.00 | 0.00 |  |  |  |  |  |  |
|  | −0.45 | −0.45 | −0.45 8.36 deg. from 0 |  |  |  |  |  |
|  |  | −0.53 | −0.90 | −0.90 8.06 deg. from 1 |  |  |  |  |
|  |  | −0.57 |  | −1.35 | −1.35 7.70 deg. From 2 |  |  |  |
|  | −0.9 | −1.02 |  |  |  | −1.02  −7.99 deg. From 0 |  |  |
|  |  | −1.10 |  |  |  |  | −1.47  −7.63 deg. From 4 |  |
|  |  | −1.14 |  |  |  |  |  | −1.92  −7.29 deg. From 5 |

Table A2-3

Calculation of new EPM for Sat. 0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sat. | 0+1+2 | 0+1+2+3 | 0+4+5 | 0+4+5+6 |
| *Ce.i.r.p.* (dBW) | 57.0 | 57.0 | 57.0 | 57.0 |
| *PR* (dB) | 21.0 | 21.0 | 21.0 | 21.0 |
| *C/Iaggr* (dB) | 20.6 | 20.5 | 20.0 | 19.9 |
| *Iaggr* (dBW) | 36.5 | 36.5 | 37.0 | 37.1 |
| *Ref. EPM* (dB) | **−0.45** | **−0.53** | **−1.02** | **−1.10** |
| *C/Inew* (dB) | **37.9** | **40.5** | **37.4** | **40.5** |
| *Inew* (dBW) | 19.1 | 16.5 | 19.6 | 16.5 |
| *C*/(*Iaggr* + *Inew*) (dB) | 20.47 | 20.43 | 19.90 | 19.86 |
| *EPM* (*Iaggr* + *Inew*) (dB) | **−0.53** | **−0.57** | **−1.10** | **−1.14** |
| Degradation (dB) | **−0.08** | **−0.04** | **−0.08** | **−0.04** |
| Off-axis angle from Sat. 0 (deg.) | 18.07 | 26.54 | −17.18 | −25.20 |
| Discrimination BO.1213 (dB) | 37.92 | 40.50 | 37.38 | 40.50 |

## 2.4 Results

The *Ref. EPM* of Sat. 0 becomes −1.14 dB with six interfering satellites. Note that this result includes the interference from outside of the coordination arc of 9 deg. The *Ref. EPM* of Sat. 0 becomes less impact if it is calculated in accordance with the Section 1 of Annex 1 to RR Appendix **30**.

# 3 Example of Scenario 2

## 3.1 Input

Sat. 0: Desired satellite

Sat. 1, 2, 3, 4, 5, 6: Satellites interfering Sat. 0. Sat. 1 apart from Sat. 0 by 3 deg., Sat 2 by 3.1 deg., Sat. 3 by 3.2 deg., Sat 4 by 2.9 deg., Sat. 5 by 2.8 deg., Sat. 6 by 2.7 deg. (Fig. A2-3).

The beams of Sat. 0 – 6: see Fig. A2-4. The service area of Sat. 0, 1, 2, 3, 4, 5, 6 are separated some distance to reduce interference each other, even though the territories may touch each other (Fig. A2-4).

e.i.r.p.: same peak value for all beams, e.g. 57 dBW/27 MHz.

Fast roll off antenna pattern: Yes. The e.i.r.p. toward another beams is reduced to meet the allowable EPM degradation.

Figure A2-3

The satellite arrangement

Diagram

Description automatically generated

Figure A2-4

The beams of Sat. 0 – 6 for Scenario 2

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## 3.2 Output

The necessary satellite power reduction toward another service areas to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30** as shown in Fig. A2-3.

## 3.3 Method

i) At first Sat. 0 is assumed to have a *Ref. EPM* of 0 dB.

ii) Sat. 1 comes such that to make the EPM degradation of Sat. 0 by 0.45 dB, the e.i.r.p. of Sat. 1 must be 42.29 dBW, reducing by 14.71 dB from 57 dBW, toward area 0 as shown in Table A2-4.

ii) Next Sat. 2 comes next to Sat. 1, such that to make the EPM degradation of Sat. 1 by more 0.45 dB, Sat. 2 must be 43.85 dBW, reducing by 13.15 dB from 57 dBW, toward area 0, and at the same time Sat. 2 must be 26.85 dBW, reducing by 30.15 dB from 57 dBW, toward area 1. Due to Sat. 2, the *Ref. EPM* of Sat. 0 becomes −0.90 dB. If the satellite beam of Sat. 2 is circular, then the e.i.r.p. of Sat. 2 toward Area 0 is 26.85 dBW and the *Ref. EPM* of area 0 remains −0.45 dB.

vi) The similar results happen when Sat. 3 to 6 come and lastly *Ref. EPM* becomes −2.7 dB at the worst-case.

v) The *Ref. EPM* of Sat. 0 would be between −0.45 dB and −2.7 dB depending on the beam shapes of Sat. 1 to Sat. 6.

Table A2-4

Necessary e.i.r.p. reduction to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix 30

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sat. | 0+1 | 0+1+2 | 0+1+2 | 0+1+2+3 | 0+4 | 0+4 | 0+4+5 | 0+4+5+6 |
| *Ce.i.r.p.* (dBW) | 57.00 | 57.00 | 57.00 | 57.00 | 57.00 | 57.00 | 57.00 | 57.00 |
| *PR* (dB) | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 |
| *C/Iaggr* (dB) | 21.0 | 20.6 | 20.6 | 20.1 | 19.7 | 19.7 | 19.2 | 18.8 |
| *Iaggr* (dBW) | 36.0 | 36.5 | 36.5 | 36.9 | 37.4 | 37.4 | 37.8 | 38.3 |
| *Ref. EPM* (dB) | **0.00** | **−0.45** | **−0.45** | **−0.90** | **−1.35** | **−1.35** | **−1.80** | **−2.25** |
| *C/Inew* (dB) | **30.6** | **30.2** | **30.2** | **29.7** | **29.3** | **29.3** | **28.8** | **28.4** |
| *Inew* (dBW) | 26.4 | 26.8 | 26.8 | 27.3 | 27.7 | 27.7 | 28.2 | 28.6 |
| *C*/(*Iaggr*+ *Inew*) (dB) | 20.55 | 20.10 | 20.10 | 19.65 | 19.20 | 19.20 | 18.75 | 18.30 |
| *EPM* (*Iaggr*+ *Inew*) (dB) | **−0.45** | **−0.90** | **−0.90** | **−1.35** | **−1.80** | **−1.80** | **−2.25** | **−2.70** |
| Degradation (dB) | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** |
| Off-axis angle φ (deg) | 3.30 | 3.41 | 0.11 | 0.11 | 3.19 | 0.11 | 0.11 | 0.11 |
| Orbital separation θ (deg) | 3.00 | 3.10 | 0.10 | 0.10 | 2.90 | 0.10 | 0.10 | 0.10 |
| BO.1213 Δ*G* at φ (dB) | −15.90 | −17.02 | −0.02 | −0.02 | −15.90 | −0.02 | −0.02 | −0.02 |
| **Reduction of *Ce.i.r.p.* (dB)** | **14.71** | **13.15** | **30.15** | **29.70** | **13.37** | **29.25** | **28.80** | **28.35** |
| *Ce.i.r.p.* of interferer (dBW) | 42.29 | 43.85 | 26.85 | 27.30 | 43.63 | 27.75 | 28.20 | 28.65 |
| pfd by EPM criterion above (dB(W/(m2 · 27 MHz))) | −120.32 | −118.76 | −135.76 | −135.31 | −118.98 | −134.86 | −134.41 | −133.96 |
| Distance from Sat. (km) Δσ = 33 deg, *El* = 38 deg | 38 090 | 38 095 | 38 095 | 38 100 | 38 084 | 38 084 | 38 079 | 38 074 |
| pfd at θ, AP**30** Annex 1 (dB(W/(m2 · 27 MHz))) | −121.76 | −120.747 | −147 | −147 | −121.76 | −147 | −147 | −147 |
| EPM or pfd | EPM | EPM | EPM | EPM | EPM | EPM | EPM | EPM |
| *C/Inew* (dB) gives EPM degradation of −0.45 dB.  Off-axis angle (deg) of Recommendation ITU-R BO.1213 gives the discrimination corresponding to *C/Inew*.  Orbital separation (deg) = Off-axis angle / 1.1 | | | | | | | | |

## 3.4 Results

The *Ref. EPM* of Sat. 0 would be between −0.45 dB and −2.7 dB depending on the beam shapes of Sat. 1 to Sat. 6.

# 4 Example of Scenario 3

## 4.1 Input

Sat. 0: Desired satellite

Sat. 1, 2, 3, 4, 5, 6: Satellites interfering Sat. 0. Sat. 1 apart from Sat. 0 by 3 deg., Sat 2 by 6 deg., Sat. 3 by 9 deg., Sat 4 by −3 deg., Sat. 5 by −6 deg., Sat. 6 by −9 deg. (Fig. A2-5).

The beams of Sat. 0 – 6: See Fig. A2-6. The service area of Sat. 0, 1, 2, 3, 4, 5, 6 are separated some distance to reduce interference each other, even though the territories may touch each other (Fig. A2-6).

e.i.r.p.: Same peak value for all beams, e.g. 57 dBW/27 MHz.

Fast roll off antenna pattern: Yes. The e.i.r.p. toward another beams is reduced to meet the allowable EPM degradation.

Figure A2-5

The satellite arrangement

Chart

Description automatically generated

Figure A2-6

The beams of Sat. 0 – 6 for Scenario 3

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中程度の精度で自動的に生成された説明

## 4.2 Output

The necessary satellite antenna discrimination toward another service areas to meet the sharing criteria in Section 1 of Annex 1 to RR Appendix **30** as shown in Fig. A2-5.

## 4.3 Method

i) At first Sat. 0 is assumed to have a *Ref. EPM* of 0 dB.

ii) Sat. 1 comes such that to make the EPM degradation of Sat. 0 by 0.45 dB, the e.i.r.p. of Sat. 1 must be 42.29 dBW, reducing by 14.71 dB from 57 dBW, toward area 0. The reason to select the spacing of 3 deg. is that the antenna gain discrimination toward Area 1 and Area 0 of 14.71 dB might be possible and realistic (Table A2-5).

ii) Next Sat. 2 comes next to Sat. 1, such that to make the EPM degradation of Sat. 0 and Sat. 1 by more 0.45 dB, Sat. 2 must be 53.83 dBW, reducing by 3.17 dB from 57 dBW, toward area 0, and at the same time Sat. 2 must be 42.73 dBW, reducing by 14.27 dB from 57 dBW, toward area 1. Due to Sat. 2, the *Ref. EPM* of Sat. 0 becomes −0.90 dB. If the satellite beam of Sat. 2 is circular, then the e.i.r.p. of Sat. 2 toward Area 0 is 28.46 dBW and the *Ref. EPM* of area 0 becomes −0.49 dB, that is, it remains about −0.45 dB.

vi) The similar results happen when Sat. 3 to 6 come and lastly *Ref. EPM* becomes −2.7 dB at the worst-case.

v) The *Ref. EPM* of Sat. 0 would be between −0.9 dB (−0.45 dB by Sat. 1 at +3 deg. and −0.45 dB by Sat. 4 at −3 deg.) and −2.7 dB depending on the beam shapes of Sat. 1 to Sat. 6

Table A2-5

Necessary satellite antenna discrimination toward another beams to meet the sharing criteria   
in Section 1 of Annex 1 to RR Appendix 30

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sat. | 0+1 | 0+1+2 | 0+1+2 | 0+1+2 | 0+1+2+3 | 0+1+2+3 | 0+4 | 0+4+5 | 0+4+5+6 |
| *Ce.i.r.p.* (dBW) | 57.00 | 57.00 | 57.00 | 42.73 | 57.00 | 57.00 | 57.00 | 57.00 | 57.00 |
| *PR*(dB) | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 | 21.0 |
| *C/Iaggr* (dB) | 21.0 | 20.6 | 20.6 | 20.6 | 20.1 | 20.1 | 19.7 | 19.2 | 18.8 |
| *Iaggr* (dBW) | 36.0 | 36.5 | 36.5 | 22.2 | 36.9 | 36.9 | 37.4 | 37.8 | 38.3 |
| *Ref. EPM* (dB) | **0.00** | **−0.45** | **−0.45** | **−0.45** | **−0.90** | **−0.90** | **−1.35** | **−1.80** | **−2.25** |
| *C/Inew* (dB) | **30.6** | **30.2** | **30.2** | **41.3** | **29.7** | **29.7** | **29.3** | **28.8** | **28.4** |
| *Inew* (dBW) | 26.4 | 26.8 | 26.8 | 1.5 | 27.3 | 27.3 | 27.7 | 28.2 | 28.6 |
| *C*/(*Iaggr* + *Inew*) (dB) | 20.55 | 20.10 | 20.10 | 20.51 | 19.65 | 19.65 | 19.20 | 18.75 | 18.30 |
| *EPM* (*Iaggr* + *Inew*) (dB) | **−0.45** | **−0.90** | **−0.90** | **−0.49** | **−1.35** | **−1.35** | **−1.80** | **−2.25** | **−2.70** |
| Degradation (dB) | **−0.45** | **−0.45** | **−0.45** | **−0.04** | **−0.45** | **−0.45** | **−0.45** | **−0.45** | **−0.45** |
| Off-axis angle φ (deg) | 3.30 | 6.60 | 3.30 | 6.60 | 9.90 | 3.30 | 3.30 | 3.30 | 3.30 |
| Orbital separation θ (deg) | 3.00 | 6.00 | 3.00 | 6.00 | 9.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| BO.1213 Δ*G* at φ (dB) | −15.90 | −27.00 | −15.90 | −27.00 | −31.39 | −15.90 | −15.90 | −15.90 | −15.90 |
| **Sat. antenna discrimination (dB)** | **14.71** | **3.17** | **14.27** | **14.27** | **−1.67** | **13.82** | **13.37** | **12.92** | **12.47** |
| *Ce.i.r.p.* of interferer (dBW) | 42.29 | 53.83 | 42.73 | 28.46 | 58.67 | 43.18 | 43.63 | 44.08 | 44.53 |
| pfd by EPM criterion above (dB(W/(m2 · 27 MHz) | −120.3 | −108.8 | −119.9 | −134.2 | −104.0 | −119.4 | −119.0 | −118.5 | −118.1 |
| Distance from Sat. (km) Δσ = 33 deg, *El* = 38 deg | 38090 | 38258 | 38090 | 38090 | 38438 | 38090 | 38090 | 38090 | 38090 |
| pfd at θ, AP**30** Annex 1 (dB(W/(m2 · 27 MHz) | −121.8 | −109.7 | −121.8 | −109.7 | −103.6 | −121.7 | −121.8 | −121.8 | −121.8 |
| EPM or pfd | EPM | EPM | EPM | EPM | EPM | EPM | EPM | EPM | EPM |
| *C/I*new (dB) gives EPM degradation of −0.45 dB.  Off-axis angle (deg) of Recommendation ITU-R BO.1213 gives the discrimination corresponding to *C/I*new.  Orbital separation (deg) = Off-axis angle / 1.1. | | | | | | | | | |

## 3.4 Results

The *Ref. EPM* of Sat. 0 would be between −0.9 dB (−0.45 dB by Sat.1 at +3 deg. and −0.45 dB by Sat. 4 at −3 deg.) and −2.7 dB depending on the beam shapes of Sat. 1 to Sat. 6

# 5 Conclusion

Three scenarios are considered. Scenarios 1 and 2 are not realistic but included for the sake of completeness. Scenario 3 above is realistic and the cumulative EPM degradation results to be between −0.9 dB (−0.45 dB by Sat. 1 at +3 deg. and −0.45 dB by Sat. 4 at −3 deg.) and −2.7 dB depending on the surrounding beam shapes of 6 interfering satellites under the condition of the allowable EPM degradation of 0.45 dB.

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