International Telecommunication Union

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Radiocommunication Sector of ITU

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(07/2019)

Assessment on limitations mentioned in Annex 7 to RR Appendix 30 (Rev.WRC-15) in the 11.7-12.7 GHz band for the GSO broadcasting-satellite service in all Regions

BO Series

Satellite delivery

International Telecommunication Union

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***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

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REPORT ITU-R BO.2465-0

Assessment on limitations mentioned in Annex 7 to RR Appendix 30 (Rev.WRC-15) in the 11.7-12.7 GHz band for the GSO broadcasting-satellite service in all Regions

(2019)

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1 Introduction

World Radiocommunication Conference 2015 (WRC-15) adopted a new Resolution (Resolution **557 (WRC-15)**) to study possible revisions of the limitations mentioned in Annex 7 to RR Appendix **30 (Rev.WRC-15)**.

This Report contains results of studies of the limitations mentioned in Annex 7 to RR Appendix **30 (Rev.WRC-15)** as instructed by Resolution **557 (WRC-15)**.

It should be noted that BSS not subject to RR Appendix **30** (12.5-12.7 GHz), in Region 3 is not the subject of consideration in accordance with Resolution **557 (WRC-15)**.

It should be emphasized that studies calling for revision of Annex 7 to RR Appendix **30 (Rev.WRC-15)** under Resolution **557 (WRC-15)** in no way was intended to have any impact whatsoever to the integrity of Appendix **30** for Regions 1 and 3.

2 Overview of current limitations in Annex 7 to Appendix 30 (Rev.WRC-15)

The Annex 7 to RR Appendix **30 (Rev.WRC-15)** contains several orbital position limitations for proposed modifications to the Region 2 Plan and for proposed new or modified assignments in the Regions 1 and 3 List applicable to specific parts of the frequency band 11.7-12.7 GHz. To simplify the readiness of this Report the following nomenclature was retained as shown in Table 1.

TABLE 1

Annex 7 to Appendix 30 (Rev.WRC-15) limitations

Annex 7 limitation	Region and Service of interfering assignments	Region and Service of impacted assignments	Frequency band	Limitation description	Associated regulatory text
A1a	Region 1 BSS	Region 2 FSS (Atlantic)	11.7-12.2 GHz	No assignments in the Region 1 List further west than 37.2°W	Section A 1)
A1b		Region 2 FSS (Pacific)		No assignments in the Region 1 List further east than 146°E	
		Region 3 BSS subject to Appendix **30**			
A2a	Region 2 BSS	Region 1 FSS (Atlantic)	12.5-12.7 GHz	No modification in the Region 2 Plan further east than 54°W	Section A 2) a)
A2b		Region 1 BSS subject to Appendix **30**	12.2-12.5 GHz	No modification in the Region 2 Plan further east than 44°W	Section A 2) b)
A2c		Region 3 FSS	12.2-12.7 GHz	No modification in the Region 2 Plan further west than 175.2°W	Section A 2) c)
		Region 1 BSS subject to Appendix **30**	12.2-12.5 GHz		
		Region 1 FSS (Pacific)	12.5-12.7 GHz		
A3a	Region 1 BSS	Region 2 FSS	11.7-12.2 GHz	No assignments in the Regions 1 and 3 List outside specific allowable portions of the orbital arc between 37.2°W and 10°E (see Table 2-2)	Section A 3)
A3b				Max. e.i.r.p. of 56 dBW for assignments in the Regions 1 and 3 List at specific allowable portions of the orbital arc between 37.2°W and 10°E (see Table 2-3)	
A3c				Max. pfd of −138 dB(W/(m^2 . 27 MHz)) at any point in Region 2 by assignments in the Regions 1 and 3 List located at 4°W and 9°E	
B	Region 2 BSS subject to Appendix **30**	Region 2 BSS subject to Appendix **30**	12.2-12.7 GHz	Required agreement of administrations having to space stations in the same cluster when an administration may locate a satellite within this cluster	Section B

Different regional allocations to the fixed-satellite service (FSS) and broadcasting-satellite service (BSS) in the 11.7-12.7 GHz frequency range are causing several interregional sharing situations between these services. BSS and FSS networks from different Regions may operate simultaneously and share orbit resource in their respective Regions. Annex 7 to RR Appendix **30 (Rev.WRC-15)** contains several orbital position limitations for proposed new or modified BSS assignments in the Regions 1 and 3 List (limitations A1a, A1b, A3a, A3b, A3c) and for proposed BSS modifications to the Region 2 Plan (limitations A2a, A2b, A2c) applicable to specific parts of the frequency band 11.7-12.7 GHz.

The FSS networks in the same frequency band are not subject to orbital position limitations.

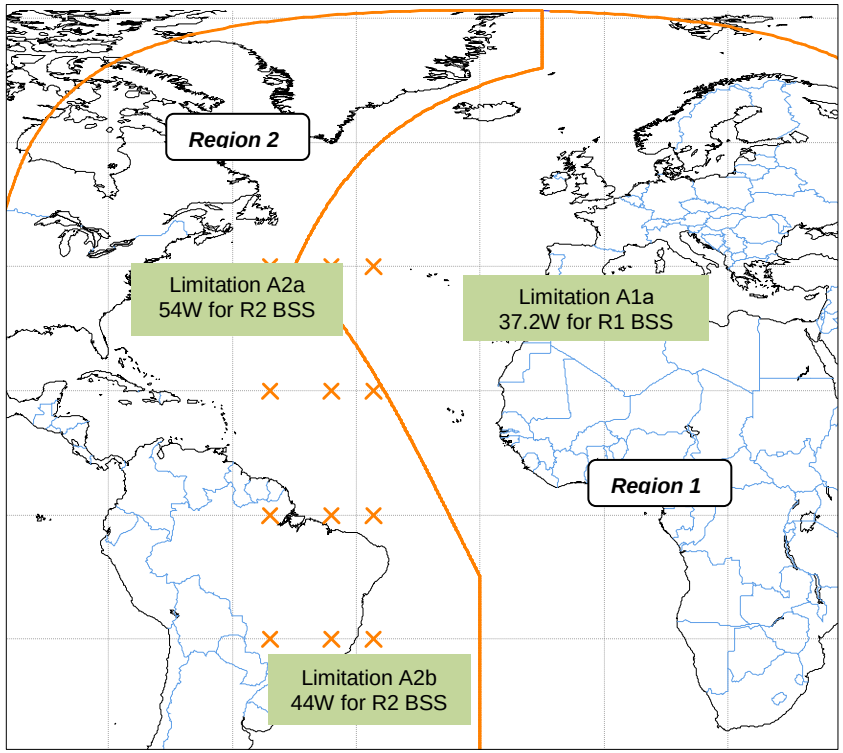
The geographical presentation of Annex 7 to RR Appendix **30 (Rev.WRC-15)** limitations A1 and A2 is shown in Fig. 1.

FIGURE 1

Geographical presentation of Annex 7 to RR Appendix 30 (Rev.WRC-15) limitations A1 and A2

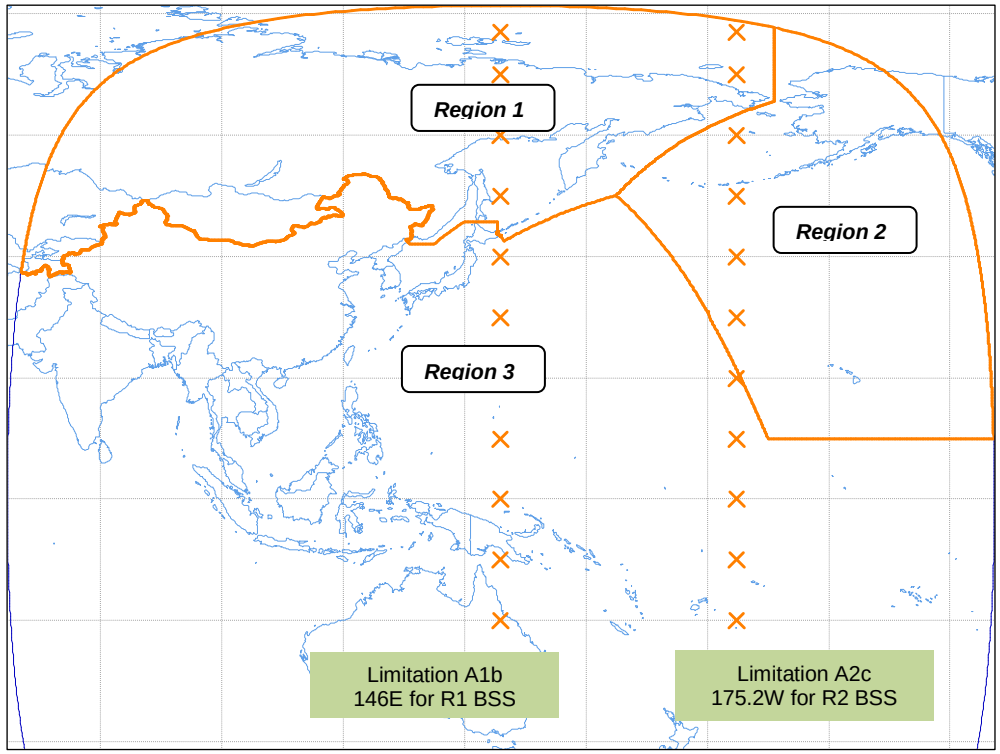
Atlantic ocean region

Limitations "A1a", "A2a", "A2b"



Pacific ocean region

Limitations "A1b", "A2c"



The limitations specified in Parts A1) and A2) of Annex 7 concern the limitations of orbital arc that must be respected by all Region 2 Plan modifications serving an area in Region 2, as well as by all new or modified assignments in the Region 1 and 3 List serving an area in Region 1, defining for particular Region in different frequency bands a specific orbital arc that can be used by these assignments.

Details of current orbital arc limitations Parts A1 and A2 of Annex 7 are presented in Table 2.

TABLE 2

Actual Annex 7 parts A1 and A2 orbital arc limitations

RR Region	Frequency band (GHz)	Geographical area	Western limitation	Eastern limitation
1	11.7-12.2	Europe, Asia (part) and Africa	37.2°W	146°E
	12.2-12.5		–	-
2	12.2-12.5	Americas	175.2°W	44°W
	12.5-12.7		175.2°W	54°W

It has to be mentioned that limitations A1 and A2 are not applicable for Region 3 BSS network. Annex 5 to Appendix **30** of the Radio Regulations specifies needed minimum elevation angles to be considered in order to obtain satisfactory quality of service. The BSS Plans have been based on the desirability of the minimum elevation angle of 20 degrees, to minimize the required e.i.r.p. level of the satellite and to reduce the effects of shadowing and the possibility of interference from terrestrial services. It is also assumed that with the minimum elevation angle of 20 degrees it would be possible to achieve good quality of service at the receiving point of BSS equipment, except in mountainous areas and in areas with high precipitations where higher elevation angles might be necessary.

However, for areas situated in latitudes above 60 degrees the minimum elevation angle of 20 degrees cannot be achieved and in such cases lower operational elevation angles must be considered.

3 Current allocations in the 11.7-12.7 GHz frequency band

The frequency band 11.7-12.7 GHz is allocated to different services as shown in Table 3.

TABLE 3

The current allocation to services in 11.7-12.7 GHz

<table>
<tr><td colspan="3">Allocation to services</td></tr>
<tr><td>Region 1</td><td>Region 2</td><td>Region 3</td></tr>
<tr><td rowspan="3">11.7-12.5
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE 5.492

5.487 5.487A</td><td>11.7-12.1
FIXED 5.486
FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.488
Mobile except aeronautical mobile 5.485</td><td rowspan="2">11.7-12.2
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE 5.492

5.487 5.487A</td></tr>
<tr><td>12.1-12.2
FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B 5.488
5.485 5.489</td></tr>
<tr><td>12.2-12.7
FIXED
MOBILE except aeronautical mobile
BROADCASTING
BROADCASTING-SATELLITE 5.492

5.487A 5.488 5.490</td><td>12.2-12.5
FIXED
FIXED-SATELLITE (space-to-Earth) 5.484B
MOBILE except aeronautical mobile
BROADCASTING
5.487 5.484A</td></tr>
<tr><td>12.5-12.75
FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B (Earth-to-space)

5.494 5.495 5.496</td><td>12.7-12.75
FIXED
FIXED-SATELLITE (Earth-to-space)
MOBILE except aeronautical mobile</td><td>12.5-12.75
FIXED
FIXED-SATELLITE (space-to-Earth) 5.484A 5.484B
MOBILE except aeronautical mobile
BROADCASTING-SATELLITE 5.493</td></tr>
</table>

4 Review of the Radio Regulations and existing documentation

4.1 Relevant provisions in the Radio Regulations

RR Appendix **30** has detailed provisions and associated coordination triggers both for modifications to the Region 2 Plan and/or Regions 1 and 3 List. In particular, the relevant provisions and associated technical criteria are:

– Article 4 of RR Appendix **30** → procedure for proposed modifications to the Region 2 Plan or Regions 1 and 3 List to coordinate with FSS or BSS subject to RR Appendix **30**.

– Article 7 of RR Appendix **30** → procedure for BSS not subject to RR Appendix **30** or FSS networks to coordinate with BSS Plan or List assignments or previously filed modifications to the Region 2 Plan or Regions 1 and 3 List.

– Annex 1 to RR Appendix **30** (sections 1, 3, 6) → criteria to determine if a proposed modification to the Region 2 Plan or proposed new or modified assignments in the Regions 1 and 3 List needs to coordinate with FSS or BSS subject to RR Appendix **30** networks or BSS networks in the frequency band 12.5-12.7 GHz in Region 3.

- The criteria here are coordination threshold pfd masks.

– Annex 4 to RR Appendix **30** → criteria to determine if a FSS or BSS not subject to RR Appendix **30** (see text in Introduction concerning BSS in the frequency band 12.5-12.7 GHz in Region 3 above) network needs to coordinate with the BSS Plan or List assignments or previously filed modifications to the Region 2 Plan or Regions 1 and 3 List.

- The criteria here are coordination threshold pfd masks applicable in the BSS service area.

– Annex 6 to RR Appendix **30** → criteria for sharing between services including summary of the assumptions used to develop the power flux-density (pfd) masks contained in Annex 1 and Annex 4 to RR Appendix **30**.

– Annex 7 to RR Appendix **30** → orbital position limitations on proposed modifications to the Region 2 Plan or for proposed new or modified assignments in Regions 1 and 3 List, specifically applicable to Region 2 BSS in 12.2-12.7 GHz and to Region 1 BSS in 11.7-12.2 GHz. Annex 7 also contains associated e.i.r.p. limits for Region 1 BSS in the portion of the arc.

Annex 6 to RR Appendix **30** is particularly useful in understanding the derivation of the Annexes 1 and 4 to RR Appendix **30** coordination threshold pfd masks, with respect to the earth station characteristics considered and the allowable $\Delta T/T$ value.

4.2 Some limitations and criteria applied to FSS and BSS subject to Appendix 30

In particular, it is interesting to consider the relationship between Annexes 1, 4, 6 and 7 to RR Appendix **30**, and to assess the factors that may have driven adoption of those provisions as well as noting factors that may have changed since WRC-03.

Some comments on the relationship between Annexes 1, 4, 6 and 7 to RR Appendix **30** (see also Fig. 2):

– Section 1 of Annex 1 to RR Appendix **30** includes a hard limit of −103.6 dB(W/(m^2 · 27 MHz)) for proposed new or modified assignments in the Regions 1 and 3 BSS List. This is equivalent to roughly a peak e.i.r.p. of 58.5 dBW/27 MHz.

– For orbital separations, taking also into account space station keeping accuracy, equal to or more than 10.57 degrees the highest pfd level without triggering coordination of FSS in any Region vis a vis BSS service area under Annex 4 to RR Appendix **30** (or, for BSS vis a vis seeking agreement with FSS in section 6 of Annex 1 to RR Appendix **30**) is also −103.6 dB(W/(m^2 · 27 MHz)).

  For orbital separation of less than 0.23° the highest operating pfd level without triggering coordination of FSS in any Region vis a vis BSS under Annex 4 to RR Appendix **30** is −147 dB(W/(m^2 · 27 MHz)) (see Fig. 2).

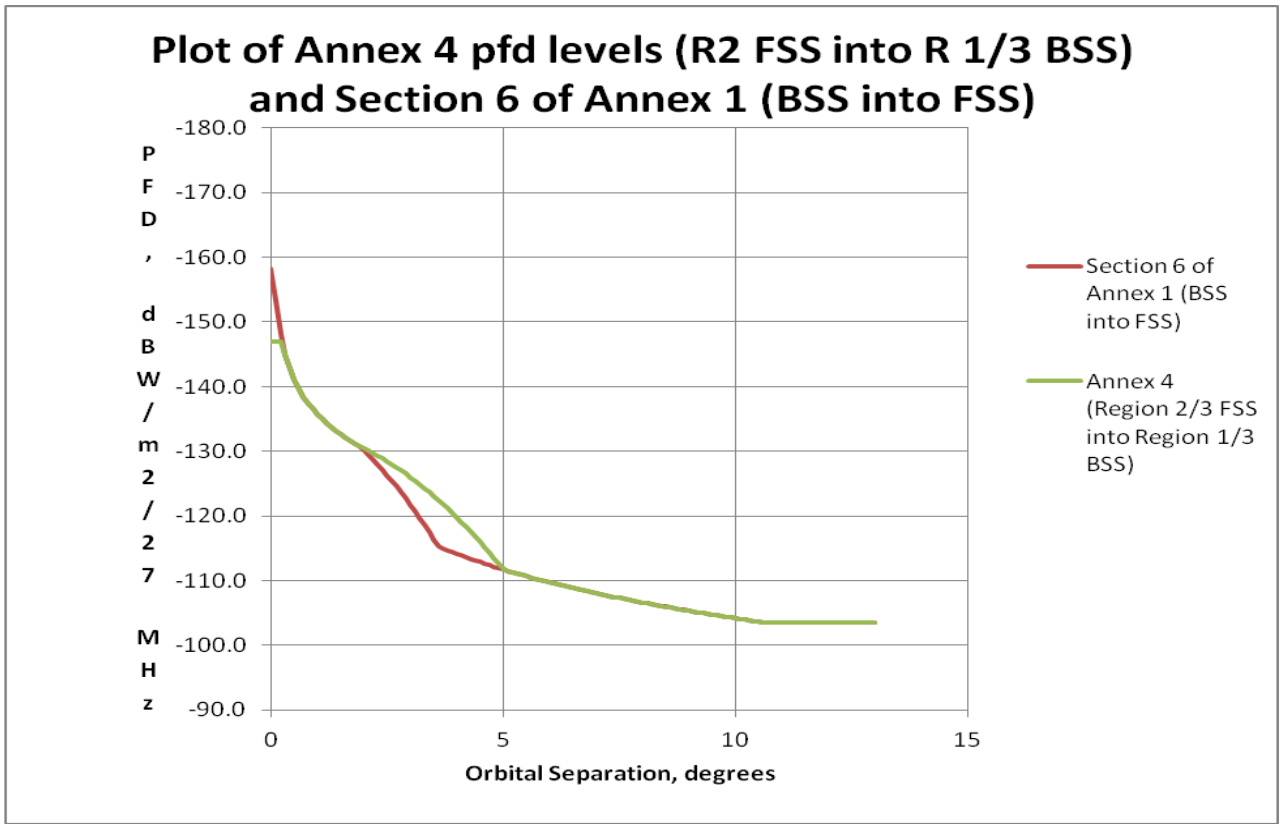
  For orbital separations less than 0.054° the highest operating pfd level without triggering coordination of BSS in any Region vis-à-vis FSS under Section 6 of Annex 1 to RR Appendix **30** is −158.2 dB(W/(m^2 · 27 MHz)) (−186.5 dB(W/(m^2 · 40 kHz))) (see Fig. 2).

– Section 3 of Annex 7 to RR Appendix **30** allows the use of certain orbital positions by Regions 1 and 3 BSS List assignments in the frequency band 11.7-12.2 GHz in the shared with FSS part of the orbital arc between Regions 1 and 2 in the Atlantic ocean side if the BSS peak e.i.r.p. level does not exceed 56 dBW/27 MHz, which is several dB lower than that in section 1/Annex 1 and Annex 4 to RR Appendix **30**.

– Different minimum and maximum earth station antenna sizes and associated noise temperature for FSS and BSS (see Annex 6 to RR Appendix **30**) led to different coordination threshold pfd masks for protecting each service.

- For small orbital separations, larger earth station antennas lead to more stringent allowed pfd levels.
- For large orbital separations, smaller earth station antennas lead to more stringent allowed pfd levels.

FIGURE 2



Other factors related to development of the sharing between FSS and BSS in different Regions:

– Different operating e.i.r.p. levels for FSS and BSS. Higher e.i.r.p. levels of BSS with respect to FSS could lead to more interference to FSS and larger orbital separations needed.

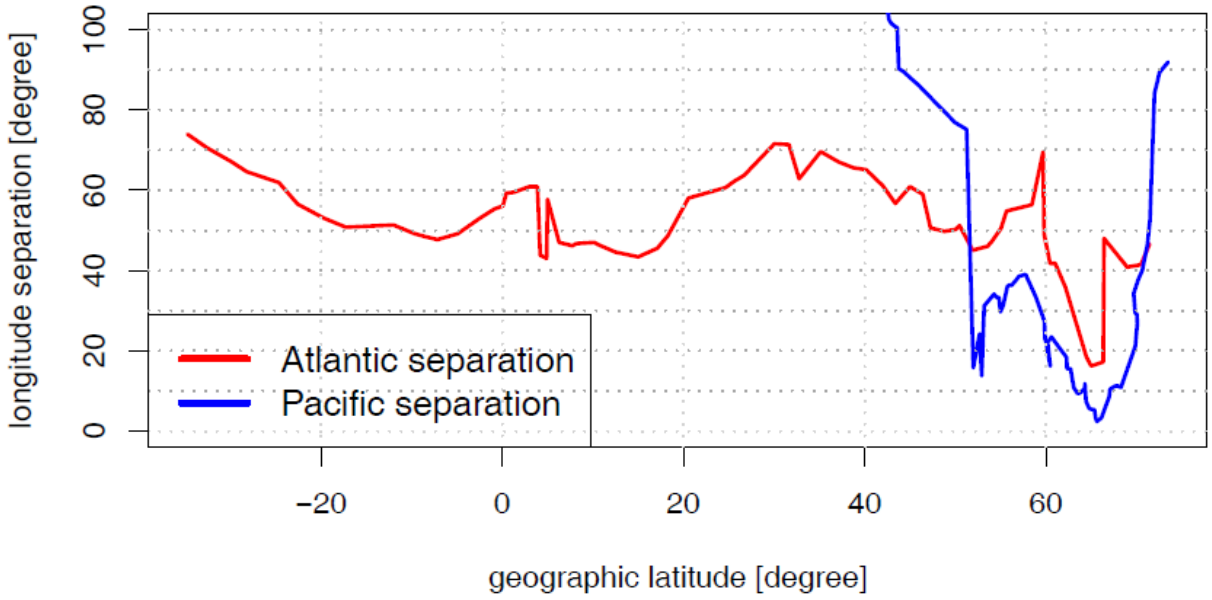
– Difference in service and coverage areas and associated beam roll off between networks serving the different Regions. Greater geographic separation facilitates sharing assuming that the service areas of FSS and BSS are not close to each other, which should at least be taken into account between Regions 1 and 2 especially in the Atlantic Ocean side.

The presence of Atlantic and Pacific oceans that could provide additional discrimination for networks in different (neighbouring) Regions.

Figure 3 illustrates the difference in the extent of the geographical separation between of Regions 1 and 2 in the Atlantic and Pacific regions. Plotted curves represent the separation between the land territories of Regions 1 and 2, measured in degrees (longitude separation), as a function of the geographical latitude due to the presence of the Atlantic and Pacific Oceans, respectively.

FIGURE 3

Geographic separation between Regions 1 and 2 land



It can be seen from the Figure that the geographical separation in the Atlantic region is uniform, and it does not decrease below 40 degrees (except in the case of the Iceland and Greenland and that is less than 2% of the total border length), whereas in the Pacific region the separation drops below 40 degrees (over about 50% of the border length) and even falls below 20 degrees in a certain range of latitudes (over about 25% of the border), reaching a minimum value of about 2 degrees. At such separations it is difficult to expect effective geographical discrimination in many areas of the Pacific region.

In the following sections, the use since WRC-03 of the shared orbital arc resource is evaluated as more FSS and BSS networks have been brought into use and planned in the shared part of the orbital arc, between Regions 1 and 2 under the current Annex 7 to RR Appendix **30 (Rev.WRC-15)**.

4.3 Definition of the term “implemented” network used in Resolution 557 (WRC-15)

Recognizing b) of Resolution **557 (WRC-15)** refers to “BSS networks implemented in accordance with the current provisions of Annex 7 to Appendix **30**”.

The “implemented” networks referred to in this Report are related to Regions 1 and 3 BSS networks in the orbital arc 37.2°W and 10°E:

- for which complete RR Appendix **4** information had been received by the Bureau under § 4.1.3 of Appendix **30** prior to 28 November 2015; and
- for which complete RR Appendix **4** information had been received by the Bureau under § 4.1.12 of Appendix **30** prior to 23 November 2019; and
- for which the complete due diligence information, in accordance with Annex 2 to Resolution **49 (Rev.WRC-15)**, had been received by the Bureau prior to 23 November 2019; and
- for which complete RR Appendix **4** information had been received by the Bureau under § 5.1.2 of Appendix **30** prior to 23 November 2019; and
- brought into use, and for which the date of bringing into use has been confirmed to the Bureau before 23 November 2019.

5 Resolution 557 (WRC-15) and Appendix 30A

There are no orbital position limitations in Appendix **30A**. One can already apply for and use the entire feeder link band within the restricted portions of the Annex 7 arc. As a result, it is not necessary to analyse the impact of removing limitations that do not exist.

5*bis* Discussion of service area vs. test points in Annex 4 and Annex 1

There is a difference in the methodology used to determine whether a BSS network is affected by co-frequency FSS (Annex 4 trigger levels in Appendix **30**) and BSS (Annex 1/section 1 trigger levels in Appendix **30**) networks.

According to Annex 4, "…coordination of a transmitting space station in the fixed satellite service (FSS) (space-to-Earth) of Region 2…is required when, under assumed free-space propagation conditions, the power flux-density over any portion of the service area of the overlapping frequency assignments in the BSS of an administration in Region 1…exceeds the following values…", and "coordination of a transmitting space station in the fixed satellite service (FSS) (space-to-Earth) in Region 1 or 3 is required when, under assumed free-space propagation conditions, the power flux-density over any portion of the service area of the overlapping frequency assignments in the BSS of an administration in Region 2 exceeds the following values…".

According to Annex 1/section 1 a), however, pfd levels which determine whether higher priority BSS frequency assignments are affected by lower priority BSS frequency assignments apply only at test points within the service area of the higher priority BSS frequency assignments.

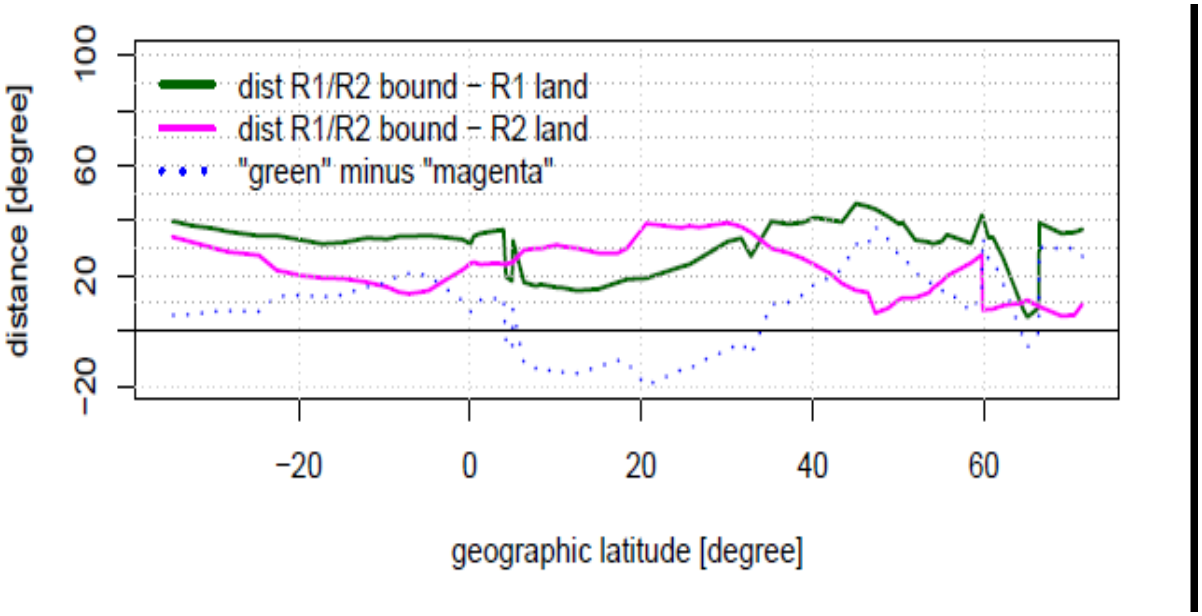
As can be observed from the above text in Annex 4, for FSS to BSS coordination, FSS networks are expected to protect the entire service area of BSS networks, not just their test points. For BSS to FSS coordination in Annex 1/section 6 is similarly based on protecting the FSS service area, so there is parity currently between the approach for BSS vis a vis FSS and vice versa.

Figure 4 illustrates the dependences of the extent of geographical separation between the boundary of Regions 1 and 2 and the land territories of Region 1 (green line) and Region 2 (magenta line); the dotted line shows the difference between the specified distances, in latitudes, where it takes negative values, the distance from the Region 2 land territory to the Regions 1/2 boundary is greater than the distance from the Region 1 land territory to the Regions 1/2 boundary. Plotted curves represent the separation between the land territories of Regions 1 and 2, measured in degrees (longitude separation) and the Region 1/Region 2 boundary, as a function of the geographical latitude due to the presence of the Atlantic Ocean.

This graphical representation allows to estimate the possible roll-off of satellite antenna from the boundary between Regions 1/2 to the land territory of specific Region (1 or 2), where test points of the BSS frequency assignment are located.

FIGURE 4

Maximum geographic separation between Region1/Region 2 boundary and Regions 1 and 2 land



6 Annex 7 limitation “A1a” (i.e. No assignments in the Region 1 List further west than 37.2°W in the frequency band 11.7-12.2 GHz)

6.1 Review of the limitation “A1a”

Limitation “A1a” calls for “No broadcasting satellite serving an area in Region 1 and using a frequency in the frequency band 11.7-12.2 GHz shall occupy a nominal orbital position further west than 37.2°W”. This restriction in the orbital position was designed to protect FSS in Region 2 in the frequency band 11.7-12.2 GHz on the Atlantic Ocean side.

The view from the orbital position 37.2°W is presented in Fig. 5. In order to quantify the practicability of extension of this orbital arc to the west, the view from 47.2°W is presented in Fig. 6. This represents the extension of allowable orbital arc of 10 degrees and is shown for illustration, to indicate the change of usable service area by moving at the GSO arc away from the limiting orbital position.

These Figures show the maximum achievable service area based on the minimum elevation angles of 20 degrees (inner contour) and 5 degrees (outer contour).

It can be seen from Fig. 5 that large parts of Western Europe and the African continent can be covered with more than 20 degrees of elevation from the orbital position 37.2°W. Figure 6 shows that the available service area is smaller if the orbital position 47.2°W is used. However, large parts of Region 1 territories, including the whole Western Africa and the Iberian Peninsula, still could be covered from the extended orbital position 47.2°W with higher elevation angles.

In addition to that, Iceland and large parts of Scandinavian countries that are situated in latitudes above 60 degrees can be covered with more than 5 degrees of elevation.

FIGURE 5

Satellite view from 37.2°W
(currently limiting orbital position)

FIGURE 6

Satellite view from 47.2°W
(extended orbital position by 10 degrees)

6.2 Summary of studies and results

Annex 1 of this Report contains sharing studies related to limitation A1a.

The sharing studies show that in all the cases the needed additional discrimination to complete or even not to affect coordination depends largely on the applied available orbital separation between the interfering and victim interfered-with networks. In addition to that, usage of increased antenna sizes and improved antenna patterns represent factors that influence and could improve the sharing situation.

The sharing studies (see Annex 1 of this Report) show that by assuming 20 dB geographic separation (provided by Atlantic Ocean) representative BSS and FSS networks serving different Regions can co-exist without triggering coordination with orbital separations as small as 0.5 degrees (for FSS versus BSS) and 2 degrees (for BSS versus FSS), considering the carrier parameters and a coverage area within −6 dB antenna gain contour.

Another study shows that by applying 20 dB due to geographical discrimination, which could be feasible due to presence of the Atlantic Ocean between Regions 1 and 2, the coordination problems would be minimal for orbital separations as small as 1.6 degrees (for BSS vs FSS) and 1.3 degrees (for FSS vs BSS), depending on the combination of interfering peak e.i.r.p. and earth station receiving antenna diameter.

Furthermore, there are large number of notified Region 2 FSS networks in the orbital arc above the Atlantic Ocean. It could be difficult for some new Region 1 BSS filings at orbital positions further West than 37.2°W and intended to operate in the area close to Region 2 to complete coordination. Therefore it could be necessary for new BSS networks to modify the service area and/or decrease the maximum e.i.r.p. over the area close to Region 2 in case of certain orbital separations with respect to existing FSS networks in order to overcome all coordination problems with Region 2 FSS networks with earlier date of receipt of the coordination request information.

In specific situations, with respect to new FSS vs. new BSS networks with certain orbital separations (i.e. new Region 2 FSS networks intending to operate in the service area close to Region 1/Region 2 boundary and new Region 1 BSS networks filed before them further west than 37.2°W intending to operate in the service area close to Region1/Region 2 boundary), deletion of limitation "A1a" could require that such new FSS networks in Region 2 modify their service area and/or decrease their maximum e.i.r.p. over the area close to Region 1 to complete the coordination.

For example, under the current rules, a Region 2 FSS satellite network operating in the 11.7-12.2 GHz frequency band and located 10° west of 37.2°W (i.e. 47.2°W) can produce pfd levels over Region 1 up to −104.2 dB(W/(m^2 · 27 MHz)) without triggering coordination with any BSS network in Region 1.

For such specific cases administrations concerned with such coordination problems would need to make additional efforts to overcome coordination problems to find mutually acceptable solution.

There are several possibilities to mitigate the problems associated with deployment at certain orbital separations of new FSS and new BSS networks having close service areas:

a) To use the test points for identification of the need of coordination under Annex 4 to RR Appendix **30** of new Region 2 FSS network with new Region 1 BSS network which occupies an orbital position further west than 37.2°W, instead of the service area definition.

b) To carry out Annex 4 examination using part of the Region 1 BSS service area on the land territory only.

c) To use tests points instead of service area only for certain orbital separations while applying Annex 4 for other orbital separations.

However, for all other cases (no close GSO orbital positions and/or no very close service areas) the relaxation of limitation A1a would not require specific mitigation as listed above or coordination between the new FSS and new BSS networks and Annex 4 could continue to apply.

Regarding assignments in the Regions 1 and 3 Plan, the studies demonstrate the protection of the Plan without any potential impact.

Regarding networks in the Regions 1 and 3 List located further East than 37.2°W for which the procedure of Article **4** of RR Appendix **30** has been completed or initiated, the studies demonstrate the protection of Article **4** networks without any potential impact.

Regarding networks in the Regions 1 and 3 List located further East than 37.2°W for which the procedure of Article 4 of RR Appendix **30** would be initiated after the possible deletion of this limitation, the studies demonstrate that in very few limited cases and for very specific conditions, a new Article **4** network located further East than 37.2°W and for which the procedure of Article **4** would be initiated after the possible deletion of this limitation could be impacted with the deletion of limitation "A1a" compared to the same situation without the deletion of such limitation. However the impact has been shown to be minimal.

7 Annex 7 limitation "A1b" (i.e. No assignments in the Region 1 List further east than 146°E in the frequency band 11.7-12.2 GHz)

7.1 Review of the limitation "A1b"

Limitation "A1b" calls for "No broadcasting satellite serving an area in Region 1 and using a frequency in the band 11.7-12.2 GHz shall occupy a nominal orbital position further east than 146°E". This restriction in the orbital position was designed to protect FSS in Region 2 in the frequency band 11.7-12.2 GHz on the Pacific Ocean side and Region 3 BSS subject to RR Appendix **30**. The view

from the limiting orbital position 146°E is presented in Fig. 7. In order to quantify the practicability of extension of this orbital arc to the east, the view from 156°E is presented in Fig. 8.

These Figures show the maximum achievable service area based on the minimum elevation angles of 20 degrees (inner contour) and 5 degrees (outer contour).

From Fig. 7 it can be seen that eastern parts of Mongolia and Russia could be covered from 146°E with more than 20 degrees of elevation. From Fig. 8, it can be seen that allowable service area shrinks but a sufficient part of Region 1 can be covered with 5 degrees of elevation from 146°E and from the extended orbital arc (156°E), which is acceptable, especially taking into account that part of this territory is located at latitudes of more than 60 degrees for which large elevation angles are unattainable from the extended orbital position 156°E.

The drawback of using such low elevation angles would increase problems with interference from existing terrestrial services and the shadowing effects (tall buildings, trees, hills) that have to be taken into account. Also, it would be very difficult to use such elevation angles in mountainous areas.

FIGURE 7

Satellite view from 146ºE
(currently limiting orbital position)

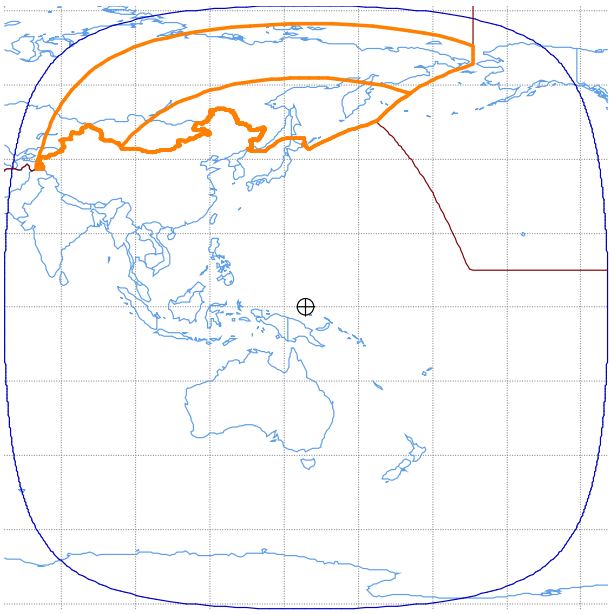


FIGURE 8

Satellite view from 156ºE
(extended orbital position by 10 degrees)

7.2 Summary of studies and results

Annex 2 to this Report contains sharing studies related to limitation A1b.

The sharing studies show that in all the cases the needed additional discrimination to complete coordination depends largely on the applied orbital separation between the interfering and interfered-with network. In addition to that, usage of increased antenna sizes and improved antenna patterns represent factors that influence and could improve the sharing situation.

The sharing studies of Annex 2 to this Report show that by assuming 20 dB geographic separation, representative BSS and FSS networks serving different Regions can co-exist with orbital separations as small as 0.5 degrees (for FSS versus BSS) and 2 degrees (for BSS versus FSS), depending on the carrier parameters and considering a coverage area within the −6 dB antenna gain contour. It is important to stress that this 20 dB geographic separation would not be achieved in the areas around the Bering Strait and pfd coordination limits could be exceeded except in cases where the aim points

of satellite beams in question (Region 1 BSS and Region 2 FSS) are sufficiently separated[1]. Analyses of certain orbital separations further demonstrate that the restriction in the orbital position further east than 146°E could be suppressed to allow an RR Appendix **30** Region 1 List new networks at an orbital position further east than 146ºE. However, there could be some specific cases (e.g. same orbital location and very close service areas) that suggest additional efforts could be needed by concerned administrations to resolve such coordination cases.

As for new possible BSS networks, due to the significant number of current Region 2 FSS network filed further east than 146°E, it could be difficult for these new networks to complete coordination with Region 2 FSS networks with earlier dates of receipt of the coordination request information.

Therefore, it could be necessary to limit the service area and/or decrease the maximum e.i.r.p. over the area close to Region 2 in order to overcome all coordination problems with Region 2 FSS networks with earlier dates of receipt of the coordination request information.

In areas with limited geographical separation between Regions 1 and 2 (i.e. Chukotka and Alaska) where the Region 2 FSS and Region 1 BSS coverage areas could be very close. Therefore new Region 2 FSS satellite networks filed could require additional efforts by administrations in the coordination process with new Region 1 BSS networks for the case of small orbital separations.

Another study shows that by applying 20 dB of discrimination, which could be feasible due to presence of the Pacific Ocean between Regions 1 and 2 in this part of the orbital arc, the coordination problems would be minimal for the orbital separations as small as 1.7 degrees (for BSS versus FSS), depending on the combination of interfering peak e.i.r.p. and earth station receiving antenna diameter.

It should be noted that this 20 dB due to geographic discrimination would not be achieved in the areas around the Bering Strait.

The sharing study shows that in the case of absence of geographic separation representative BSS and FSS networks serving different Regions can co-exist with orbital separations of 3.5 degrees (for Region 2 FSS versus Region 1 BSS) and 5.8 degrees (for Region 2 BSS versus Region 1 FSS), depending on the carrier parameters (for the edge of coverage limited to the −6 dB antenna gain), assuming that a protected part of the service area is over land.

Regarding assignments in the Regions 1 and 3 Plan, the studies demonstrate the protection of the Plan without any potential impact.

Regarding networks in the Regions 1 and 3 List located further West than 146°E for which the procedure of Article **4** of RR Appendix **30** has been completed or initiated, the studies demonstrate the protection of Article **4** networks without any potential impact.

Regarding networks in the Regions 1 and 3 List located further West than 146°E for which the procedure of Article **4** of RR Appendix **30** would be initiated after the possible deletion of this limitation, the studies demonstrate that in very few limited cases and for very specific conditions, a new Article **4** network located further West than 146°E for which the procedure of Article **4** would be initiated after the possible deletion of this limitation could be impacted with the deletion of limitation “A1b” compared to the same situation without deletion of such limitation. However the impact is assumed to be minimal.

Given the results of studies and limited geographical separation between Regions 1 and 2, deleting Limitation A1b is not practicable.

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[1] For instance, in case the Region 1 BSS pfd level produced in the Region 2 territory is limited by the value −158.2 dB(W/(m^2 · 27 MHz)) and (−186.5 dB(W/(m^2 · 40 kHz)) (see Annex 4 to RR Appendix **30**), the Region 2 FSS protection will be guaranteed even at orbital separations less than 0.054 degrees.

8 Annex 7 limitation "A2a" (i.e. No modifications in the Region 2 Plan further east than 54°W in the frequency band 12.5-12.7 GHz)

8.1 Review of the limitation A2a

Limitation "A2a" calls for "No broadcasting satellite serving an area in Region 2 and using a frequency in the frequency band 12.5-12.7 GHz shall occupy a nominal orbital position further east than 54°W". This restriction in the orbital position was designed to protect FSS in Region 1 in the frequency band 12.5-12.7 GHz on the Atlantic Ocean side.

The view from the orbital position 54°W is presented in Fig. 9. In order to quantify the practicability of extension of this orbital arc to the east, the view from 44°W is also presented in Fig. 10.

This represents the extension of allowable orbital arc of 10 degrees, which illustrates the change of usable service area moving at the GSO arc away from the limiting orbital position 54°W.

These Figures show the maximum achievable service area based on the minimum elevation angles of 20 degrees (inner contour) and 5 degrees (outer contour).

Figure 9 shows that the whole South American continent and the Caribbean area can be covered from this orbital position with more than 20 degrees of elevation. Also, large parts of the North American continent can be covered with such elevation angle as well. Figure 10 shows that moving 10 degrees to the east does not bring any considerable change in the available service area.

In addition to that, large parts of Canada situated in latitudes above 60 degrees can be covered with more than 5 degrees of elevation.

FIGURE 9

Satellite view from 54°W
(currently limiting orbital position)

FIGURE 10

Satellite view from 44°W
(extended orbital position by 10 degrees)

8.2 Summary of studies and results

Annex 3 to this Report contains sharing studies related to limitation A2a.

The sharing studies show that in all the cases the needed additional discrimination to complete or even not to affect coordination depends largely on the applied available orbital separation between

the interfering and interfered-with network. In addition to that, usage of increased antenna sizes and improved antenna patterns represent factors that influence and could improve the sharing situation.

The sharing studies of Annex 3 to this Report shows that by assuming 20 dB geographic separation (provided by Atlantic Ocean) representative BSS and FSS networks serving different Regions can co-exist without triggering coordination with orbital separations as small as 0.5 degrees (for FSS versus BSS) and 1.9 degrees (for BSS versus FSS), depending on the carrier parameters and considering a coverage area limited to the −6 dB antenna gain contour.

Another study shows that by applying 20 dB due to geographic discrimination, which could be feasible due to the presence of the Atlantic Ocean between Regions 1 and 2, the coordination problems would be minimal for orbital separations as small as 1.8 degrees (for BSS vs FSS) and 1.6 degrees (for FSS vs BSS), depending on the combination of interfering peak e.i.r.p. and earth station receiving antenna diameter.

Furthermore, there are a large number of notified Region 1 FSS networks in the orbital arc above the Atlantic Ocean. It could be difficult for some new Region 2 BSS filing at orbital positions further east than 54°W and intended to operate in the area close to Region 1 to complete coordination. Therefore, it could be necessary to new BSS networks to modify the service area and/or decrease the maximum e.i.r.p. over the area close to Region 1 in case of certain orbital separations with respect to existing FSS networks in order to overcome all coordination problems with Region 1 FSS networks with earlier dates of receipt of the coordination request information.

In specific situations with respect to new FSS vs. new BSS networks with certain orbital separations (i.e. new Region 1 FSS networks intending to operate in the service area close to the Region 2/Region 1 boundary and new Region 2 BSS networks filed before them further east than 54°W intending to operate in the service area close to Region2/Region 1 boundary, Deletion of Limitation “A2a” could require that such new FSS networks in Region 1 modify their service area and/or decrease their maximum e.i.r.p. over the area close to Region 2 to complete the coordination. For such specific cases administrations concerned with such coordination problems would need to make additional effort to overcome coordination problems to find mutually acceptable solution.

There are several possibilities to mitigate the problems associated with deployment at certain orbital separations of new FSS and new BSS networks having close service areas:

a) To use the test points for identification of the need of coordination under Annex 4 to RR Appendix **30** of new Region 1 FSS network with new Region 2 BSS network which occupies an orbital position further east than 54°W, instead of the service area definition for the coordination under Annex 4.

b) To carry out Annex 4 examination using part of the Region 2 BSS service area on the land territory only.

c) To use tests points instead of service area only for certain orbital separations while applying Annex 4 for other orbital separations.

However, for all other cases (no close GSO orbital positions and/or no very close service areas) the relaxation of A2a limitation would not require specific mitigation as listed above or coordination between the new FSS and new BSS networks and Annex 4 could continue to apply.

Regarding assignments in the Region 2 Plan, the studies demonstrate the protection of the Plan without any potential impact.

Regarding Region 2 networks located further West than 54°W for which the procedure of Article **4** of RR Appendix **30** has been completed or initiated, the studies demonstrate the protection of Article **4** networks without any potential impact.

9 Annex 7 limitation "A2b" (i.e. No modifications in the Region 2 Plan further east than 44°W in the frequency band 12.2-12.5 GHz)

9.1 Review of the limitation "A2b"

Limitation "A2b" calls for "No modification in the Region 2 Plan further east than 44°W in the frequency band 12.2-12.5 GHz". This restriction in the orbital position was designed to protect the Region 1 BSS subject to RR Appendix **30** in the frequency band 12.2-12.5 GHz from BSS operating in Region 2.

In the lower part of the Region 2 BSS band (12.2-12.5 GHz) the limiting orbital position at the east side is 44°W. The view from the orbital position 44°W is presented in Fig. 11. In order to quantify the practicability of extension of this orbital arc to the east, the view from 34°W is presented in Fig. 12. This extension of the allowable orbital arc of 10 degrees shows the decrease of usable service area if we move at the GSO arc further east from the limiting orbital position.

These Figures show the maximum achievable service area based on the minimum elevation angles of 20 degrees (inner contour) and 5 degrees (outer contour).

Figure 11 shows that the whole South American continent and the Caribbean area can be covered from the orbital position 44°W with more than 20 degrees of elevation. Also, large parts of the North American continent can be covered with such elevation angle as well. If we move at the GSO arc 10 degrees to the east, it can be seen from Fig. 12 that there is no significant change in the part of Region 2 area that can be covered with the minimum elevation angle of 20 degrees.

In addition to that, big parts of Canada situated in latitudes above 60 degrees can be covered with more than 5 degrees of elevation.

FIGURE 11

Satellite view from 44°W
(currently limiting orbital position)

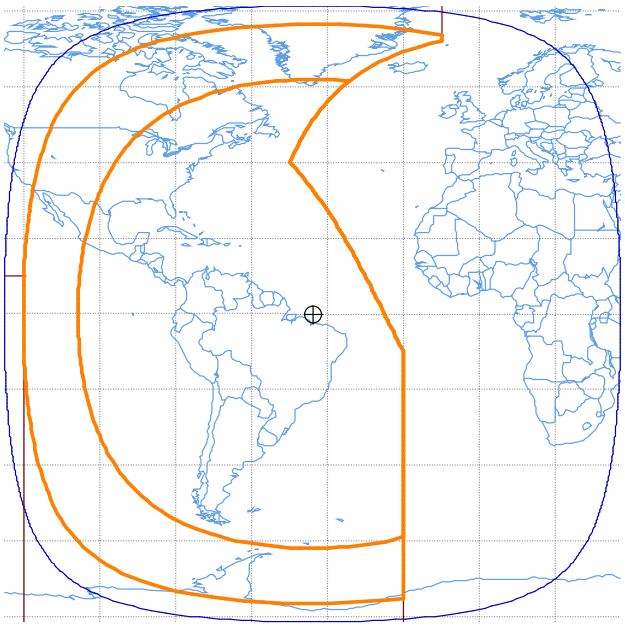


FIGURE 12

Satellite view from 34°W
(extended orbital position by 10 degrees)

9.2 Summary of studies and results

Annex 4 of this Report contains sharing studies related to limitation A2b.

The sharing studies show that in all the cases the needed additional discrimination to complete coordination depends largely on the applied orbital separation between the interfering and victim network. In addition to that, usage of increased antenna sizes and improved antenna patterns represent factors that influence and could improve the sharing situation.

The sharing studies of Annex 4 of this Report shows that representative BSS networks serving different Regions can co-exist without triggering coordination with orbital separations as small as 2 degrees (Region 2 BSS versus Region 1 BSS) and 2.1 degrees (Region 1 BSS versus Region 2 BSS), depending on the carrier parameters and geographic separation assumed and considering a coverage area limited to the −6 dB antenna gain contour. These small orbital separations further demonstrate that the restriction in the orbital position further east than 44°W could be suppressed to allow a RR Appendix **30** Region 2 Plan modification at an orbital position further east than 44°W.

Another study shows that by applying 20 dB due to geographic separation, which could be feasible due to presence of the Atlantic Ocean between Regions 1 and 2, the coordination problems would be minimal for the orbital separations as small as 2.2 degrees (for Region 2 BSS versus Region 1 BSS) and 2.1 degrees (for Region 1 BSS versus Region 2 BSS), depending on the combination of interfering peak e.i.r.p. and earth station receiving antenna diameter.

Regarding assignments in the Region 2 Plan, the studies demonstrate the protection of the Plan without any potential impact.

Regarding Region 2 networks located further West than 44°W for which the procedure of Article **4** has been completed or initiated, the studies demonstrate the protection of Article **4** networks without any potential impact.

10 Annex 7 limitation “A2c” (i.e. No modifications in the Region 2 Plan further west than 175.2°W in the frequency band 12.2-12.7 GHz)

10.1 Review of the limitation “A2c”

Limitation A2c calls for “No broadcasting satellite serving an area in Region 2 and using a frequency in the band 12.2-12.7 GHz shall occupy a nominal orbital position further west than 175.2°W”. This restriction in the orbital position was designed to protect FSS in Region 1 in the frequency band 12.5-12.7 GHz, BSS in Region 1 subject to RR Appendix **30** in the frequency band 12.2-12.5 GHz and FSS in Region 3 in the band 12.2-12.7 GHz on the Pacific Ocean side.

The view from the orbital position 175.2°W is presented in Fig. 13. To quantify the practicability of extension of this orbital arc to the west, the view from 174.8°E is presented in Fig. 14.

These Figures show the maximum achievable service area based on the minimum elevation angles of 20 degrees (inner contour) and 5 degrees (outer contour).

FIGURE 13

Satellite view from 175.2°W
(currently limiting orbital position)

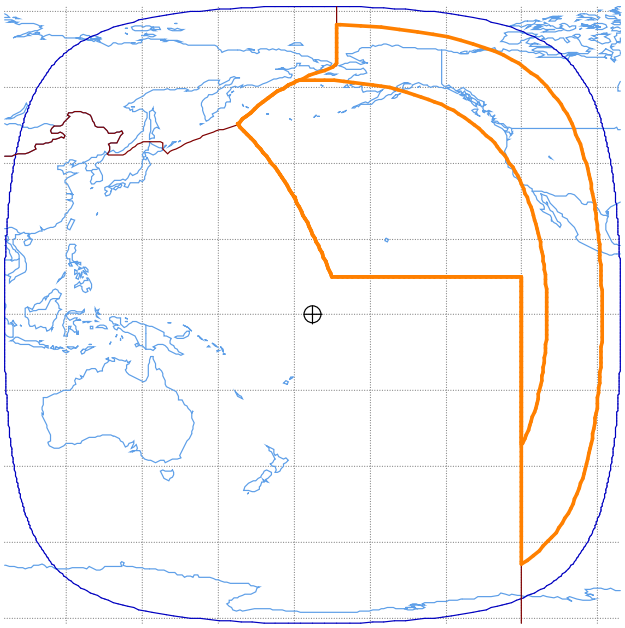


FIGURE 14

Satellite view from 174.8°E
(extended orbital position by 10 degrees)

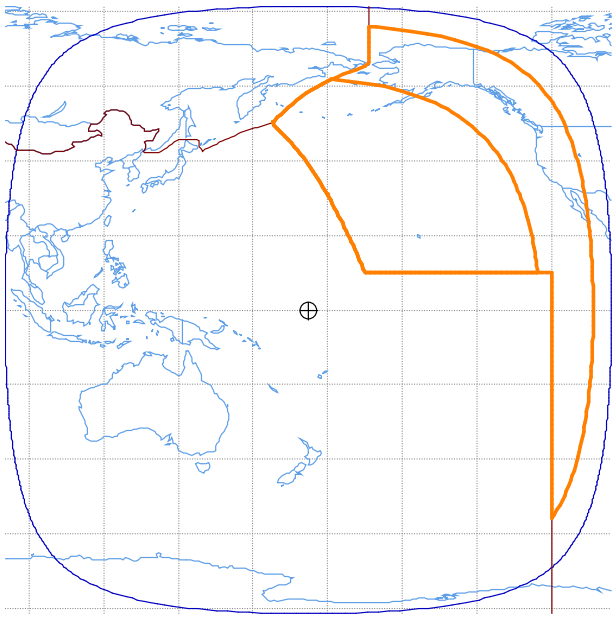


Figure 13 shows that the South American continent is not visible at all from this orbital position. Also, the North American continent cannot be covered with more than 20 degrees of elevation (except Hawaii and small parts of Alaska). From Fig. 14 it can be seen that achievable service area with the minimum elevation angle of 20 degrees shrinks even more, making the usage of this extended orbital arc unpractical, as the American continents cannot be covered with good elevation angle. If we move further west from 174.8°E the available service area additionally shrinks to the minimum.

The drawback of using such low elevation angles would increase problems with interference from existing terrestrial services and the shadowing effects (tall buildings, trees, hills) that have to be taken into account. Also, it would be very difficult to use such elevation angles in mountainous areas.

10.2 Summary of studies and results

Annex 5 of this Report contains sharing studies related to limitation A2c.

The sharing studies show that in all the cases the needed additional discrimination to complete coordination depends largely on the applied orbital separation between the interfering and interfered-with network. In addition to that, usage of increased antenna sizes and improved antenna patterns represent factors that influence and could improve the sharing situation.

The sharing studies of Annex 5 of this Report show that by assuming 20 dB geographic separation representative BSS and FSS networks serving different Regions can co-exist without triggering coordination with orbital separations as small as 0.5 degrees (for Region 1 FSS versus Region 2 BSS) and 1.9 degrees (for Region 2 BSS versus Region 1 FSS), depending on the carrier parameters and considering a coverage area limited to the −6 dB antenna gain contour.

It is important to stress that this 20 dB geographic separation would not be achieved in the areas around the Bering Strait, therefore significant service area separation would not be achieved, so that orbital separation between networks would be the only source of discrimination.

The sharing study shows that in the case of absence of geographic separation representative BSS and FSS networks serving different Regions can co-exist with orbital separations of 4.4 degrees (for

Region 1 FSS versus Region 2 BSS) and 5.8 degrees (for Region 2 BSS versus Region 1 FSS), depending on the carrier parameters (for the edge of coverage limited to the −6 dB antenna gain contour case).

However, there could be some specific cases (e.g. same orbital location and very close service areas) that suggest additional efforts by concerned administrations to resolve such coordination case.

Another study shows that by applying 20 dB due to geographic discrimination, which could be feasible due to presence of the Pacific Ocean between Regions 1 and 2 in this part of the orbital arc, the coordination problems would be minimal for orbital separations as small as 1.6 degrees (for Region 2 BSS versus Region 3 FSS) and 1.6 degrees (for Region 3 FSS versus Region 2 BSS), depending on the combination of interfering peak e.i.r.p. and earth station receiving antenna diameter. It should be noted that this 20 dB due to geographic discrimination would not be achieved in the areas around the Bering Strait and pfd coordination limits could be exceeded.

As for new possible BSS networks, due to the significant number of current Regions 1 FSS network filed further west than 175.2°W, it could be difficult for these new networks to complete coordination. with Region 1 FSS networks with earlier dates of receipt of the coordination request information.

Therefore it could be necessary to limit the service area and/or decrease the maximum e.i.r.p. over the area close to Region 2 in order to overcome all coordination problems with Region 2 FSS networks with earlier dates of receipt of the coordination request information. It has to also be stressed the current situation gives considerable overprotection to FSS networks.

In areas with limited geographical separation between Regions 1 and 2 (i.e. Chukotka and Alaska) where the Region 1 FSS and Region 2 BSS coverage areas could be very close. Therefore, new Regions 1 and 3 FSS satellite networks filed could require additional efforts by administrations in the coordination process with new Region 2 BSS networks for the case of small orbital separations.

Regarding assignments in the Region 2 Plan, the studies demonstrate the protection of the Plan without any potential impact.

Regarding Region 2 networks located further East than 175.2°W for which the procedure of Article **4** of RR Appendix **30** has been completed or initiated, the studies demonstrate the protection of Article **4** networks without any potential impact.

Given the results of studies and limited geographical separation between Regions 1 and 2, deleting Limitation A2c is not practicable.

11 Annex 7 limitation “A3a” (i.e. No assignments in the Regions 1 and 3 List outside specific positions in the frequency band 11.7-12.2 GHz)

11.1 Review of the limitation “A3a”

Section 3 of Annex 7 to RR Appendix **30** defines orbital position and e.i.r.p. limitations in the orbital arc 37.2°W-10°E, which were developed to preserve access to the geostationary-satellite orbit by the Region 2 fixed-satellite service in the frequency band 11.7-12.2 GHz. The limitations state that the orbital position associated with any proposed new or modified assignment in the Regions 1 and 3 List of additional uses shall lie within one of the portions of the orbital arc listed in Table 4.

TABLE 4

Allowable portions of the orbital arc between 37.2°W and 10°E for assignments in the Regions 1 and 3 Plan and List

Allowable orbital position										
37.2°W to 36°W	33.5°W to 32.5°W	30°W to 29°W	26°W to 24°W	20°W to 18°W	14°W to 12°W	8°W to 6°W	4°W	2°W to 0°E	4°E to 6°E	9°E

NOTE – Table 4 is similar to Table 1 in Annex 7 to RR Appendix **30 (Rev.WRC-15)**.

The original idea of Annex 7 section A3 limitations was to impose to Regions 1 and 3 Plan the limitation of usage of orbital positions that are different from the nominal positions from the Regions 1 and 3 Plan in the orbital arc 37.2°W – 10°E, and to use this available 6° spacing for usage of FSS networks operating over Region 2 areas.

Thus, it was possible to put two FSS networks spaced 1° away in the available sub-arc, assuring at the same time 2.5° spacing with respect to adjacent Region 1 and 3 Plan assignments at their nominal orbital positions of the Regions 1 and 3 Plan.

The actual Annex 7 does not allow such a scenario as the original spacing of 6° does not exist anymore in the current Regions 1 and 3 Plan and List inside the orbital arc 37.2°W – 10°E.

The imposed limitations concerned, and still concern, only planned BSS networks. Unplanned FSS networks serving Region 2 areas are free to use any orbital position inside this orbital arc.

In addition to that, the original Annex 7 to Appendix **30** was created having in mind the satellite technology of the seventies, using analogue modulation, low quality receiving earth station antennas and receivers, as well as satellite transmitting elliptical beams. Due to significant improvement of satellite technology over the last 4 decades and today's exclusive usage of digital modulation, the current Annex 7 limitations with decreased available spacing between nominal orbital positions of the Regions 1 and 3 Plan can still assure the coexistence of Region 1 and 3 planned BSS networks and the unplanned FSS networks operating over Region 2 areas.

The available orbital sub-arcs to be used by the FSS networks operating over Region 2 areas are presented in Table 5.

Table 5 clearly shows that the original idea from WARC-77 of 6° spacing is not usable any more. Current Annex 7 text allows only 4 sub-arcs that are 4° wide (24°W – 20°W, 18°W – 14°W, 12°W – 8°W, 0° – 4°E). In these sub-arcs one unplanned FSS network could be placed with 2° spacing with respect to adjacent planned BSS networks. Other sub-arcs are narrower and might be used only with very big spatial discrimination between corresponding FSS and BSS transmitting satellite beams, thus imposing additional constraints to successful coordination and future use of unplanned FSS networks in the orbital arc 37.2°W – 10°E.

TABLE 5

Forbidden portions of the orbital arc 37.2°W – 10°E for new or modified assignments in the Region 1 and 3 Plan and List in the frequency band 11.7–12.2 GHz

Orbital Position	36°W to 33.5° W	32.5°W to 30°W	29°W to 26°W	24°W to 20°W	18°W to 14°W	12°W to 8°W	6°W to 4°W	4°W to 2°W	0° to 4°E	6°E to 9°E	9°E to 10°E
Available orbital sub-arc	2.5°	2.5°	3°	4°	4°	4°	2°	2°	4°	3°	1°

11.2 Definition of orbital arc segments, where it is allowable to apply additional regulatory measures to protect small antennas of the implemented networks

As noted above in this section the current Section 1 of Annex 1 coordination threshold pfd mask does not include the protection of receiving earth station antennas with diameters smaller than 60 cm. However according to *recognizing b)* of Resolution **557** (**WRC-15**) BSS networks implemented in accordance with the current provisions of Annex 7 to RR Appendix **30** shall continue to be protected.

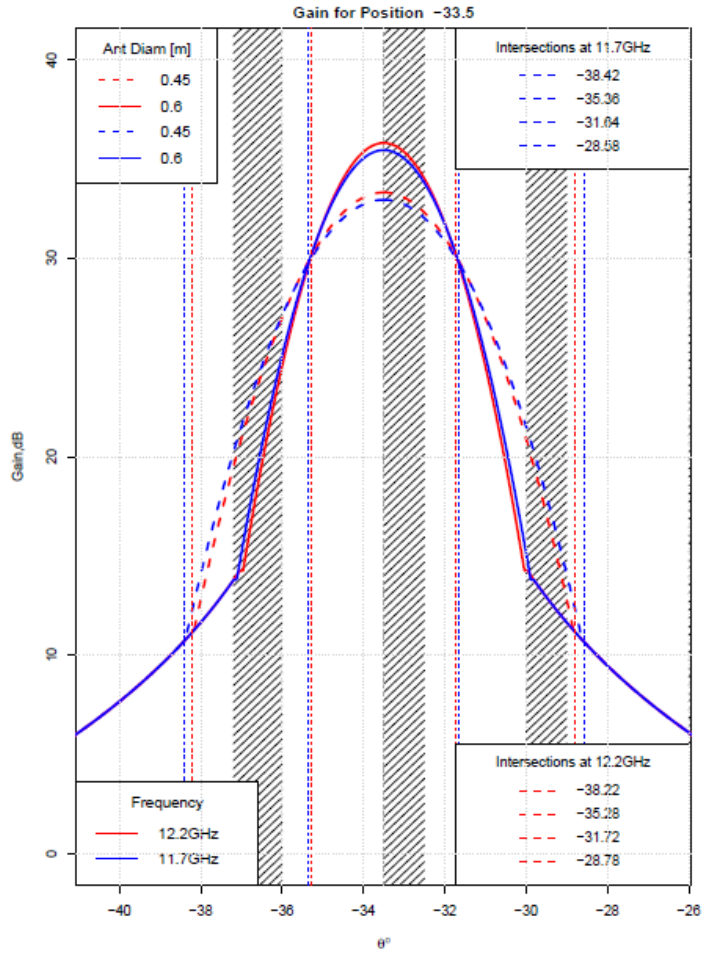
That means that networks with antennas smaller than 60 cm need to be provided the protection that they had in the presence of forbidden portions of the orbital arc. While it is obvious that no additional protection conditions are required, and not allowed, to apply from networks located in previously allowed parts of the orbital arc (shaded segments in the figures below). Otherwise, the protection of networks with antennas smaller than 60 cm could increase when applying additional measures, compared to the protection that networks had before limitation A3a was deleted, because, as study #3 showed, networks in allowable orbital arc sections are allowed to cause networks with small antennas interference at which $\Delta T/T$ is up to 41.27%. For implemented networks with small antennas in the GSO positions 33.5°W, 30°W and 4.8°E, the possible allowable relative noise increase ($\Delta T/T$) could be up to 29.1%, 26.5% and 27.4% (see § 3.6 of Annex 6).

Thus, protection of receiving stations of the implemented networks with antennas smaller than 60 cm should be ensured only from new networks in those segments of previously forbidden GSO arc portions, when deploying networks in which protection of these stations could change (decrease) compared to the current situation.

Orbital arc segments in which additional measures ensuring the protection for antennas smaller than 60 cm are acceptable to apply are defined based on the location of forbidden and allowable orbital arc portions and on the difference in off-axis radiation patterns of antennas 60 cm in diameter (the minimum antenna size protected by the pfd mask of Section 1 Annex 1) compared to 45 and 40 cm antennas in the corresponding GSO orbital positions.

The graphs below show the off-axis antenna gains at the frequency of 11.7 GHz (blue lines) and at the frequency of 12.2 GHz (red lines) as a function of geocentric orbital separation.

The Figures below show the points of intersection of the above mentioned antenna diagrams (marked by dotted lines), which, together with the location of the allowable portions, determine the orbital arc segments where additional regulatory measures are allowable.



Orbital arc segments in orbital position 33.5°W:

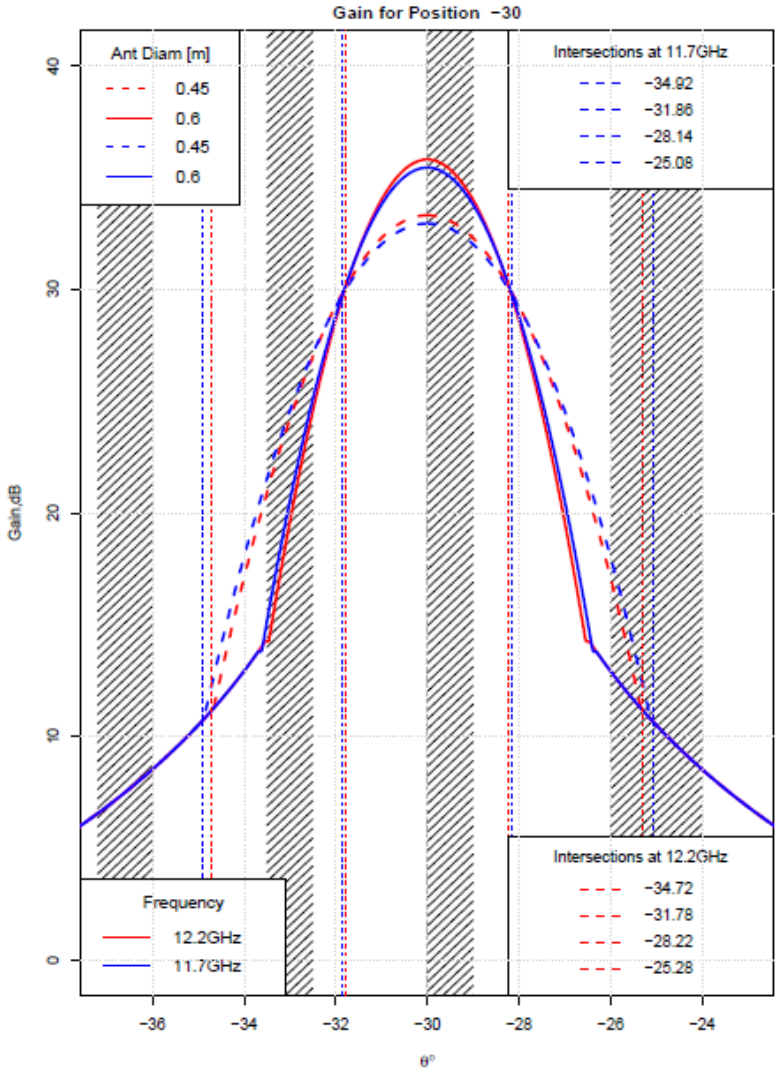
For frequency 11.7 GHz	For frequency 12.2 GHz
36.0°W < θ ≤ 35.36°W;	36.0°W < θ ≤ 35.28°W;
31.64°W ≤ θ < 30.0°W;	31.72°W ≤ θ < 30.0°W;
29.0°W < θ ≤ 28.58°W;	29.0°W < θ ≤ 28.78°W;

Orbital arc segments in the orbital arc 37.2°W …10°E, where the additional protection measures could apply in relation to implemented network having antenna size 45 cm in orbital position 33.5°W in the frequency band 11.7-12.2 GHz:

36.0°W < θ ≤ 35.28°W;

31.72°W ≤ θ < 30.0°W;

29.0°W < θ ≤ 28.58°W;



Orbital arc segments in orbital position 30°W:

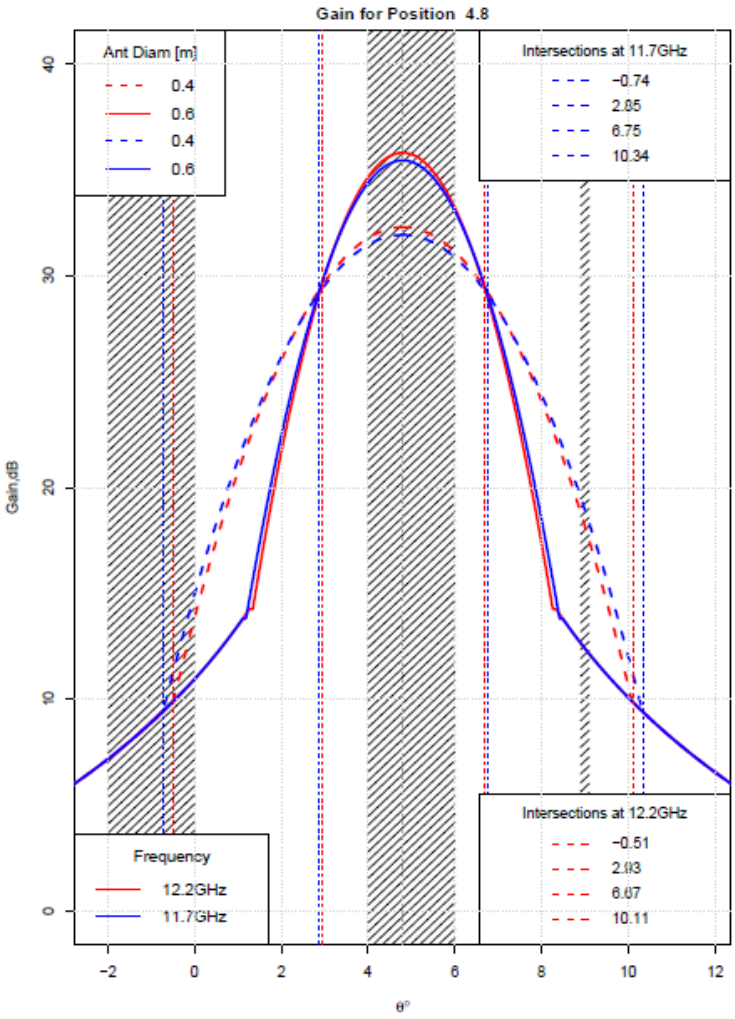
For frequency 11.7 GHz	For frequency 12.2 GHz
34.92°W ≤ θ< 33.5°W;	34.72°W ≤ θ< 33.5°W;
32.5°W < θ ≤ 31.86°W;	32.5°W < θ ≤ 31.78°W;
28.14°W ≤ θ < 26.0°W.	28.22°W ≤ θ < 26.0°W.

Orbital arc segments in the orbital arc 37.2°W…10°E, where the additional protection measures could apply in relation to implemented networks having antennas size 45 cm in orbital position 30°W in the frequency band 11.7-12.2 GHz:

34.92°W ≤ θ< 33.5°W;

32.5°W < θ ≤ 31.78°W;

28.22°W ≤ θ < 26.0°W.



Orbital arc segments in orbital position 4.8°E:

For frequency 11.7 GHz	For frequency 12.2 GHz
$0 < \theta \leq 2.85°E$;	$0 < \theta \leq 2.93°E$;
$6.75°E \leq \theta < 9.0°E$;	$6.67°E \leq \theta < 9.0°E$;
$9°E < \theta \leq 10°E$.	$9°E < \theta \leq 10°E$.

Orbital arc segments in the orbital arc 37.2°W…10°E, where the additional protection measures could apply in relation to implemented network having antenna size 40 cm in orbital position 4.8°E in the frequency band 11.7-12.2 GHz:

$0 < \theta \leq 2.93°E$;

$6.67°E \leq \theta < 9.0°E$;

$9°E < \theta \leq 10°E$.

These results were used in the development of regulatory measures regarding the deletion of limitation A3a.

11.3 Summary of studies and results

Annex 6 of this Report contains detailed of each sharing studies related to Limitation A3a.

All the studies described below consider intra-service sharing within one Region, that is, Region 1 BSS with receiving earth station antennas smaller than 60 cm versus Region 1 BSS within the orbital arc 37.2°W – 0°E.

Study #1 shows that regarding intra-service sharing (i.e. Region 1 BSS vs Region 1 BSS), a noise increase by 0-7.85 dB in the worst case of the interference level (relative to the $\Delta T/T$ obtained from two networks in adjacent allowable portions and only for two orbital positions – relative of 6%) will be received by an earth station with antenna size 40 cm (that an incumbent is forced to accept in case WRC-19 would decide to remove the Annex 7 limitation A3a (section A3 of Annex 7 to RR Appendix **30**) if no additional specific measures would be considered. This result was obtained in a sequential analysis of all allowable portions of the orbital arc considering two interfering satellites in compliance with Annex 1 pfd mask when they are placed in the adjacent allowable portions in the worst positions in terms of causing interference, and it is recognized that the interference will be higher if more than two interfering satellites are to be considered.

Therefore, there may be a risk that an existing satellite network implementing earth stations with antenna size 40 cm under the current regulatory regime defined by current orbit limitations in Annex 7 to RR Appendix **30**, would not be able to continue its operation due to the possible additional level of interference that an incumbent might be forced to accept, unless no additional specific measures are considered. Such situation would be in contradiction to *recognizing b)* of Resolution **557** (**WRC-15**), stating: "that existing FSS networks operating in the frequency bands mentioned in *considering b)* and BSS networks implemented in accordance with the current provisions of Annex 7 to Appendix **30** shall continue to be protected". Study #1 shows that the current protection criteria in Annex 1 do not provide protection of antennas smaller than 60 cm for Region 1 and 3 BSS in particular antenna size 40 cm, however, the situation is much better with antenna size 45 cm.

At present there are five assignments in the orbital arc 37.2°W – 10°E having antennas smaller than 60 cm in three different orbital locations sent to the Bureau before WRC-15: 33.5ºW, 30ºW, 4.8ºE. According to Study #1 noise increase in the worst case of the interference level for these orbital locations, and antenna 40 cm amount to 0.25/0.23 dB, 1.1/1.1 dB, 2.16/2.4 dB accordingly. But all mentioned assignments have antenna size 45 cm, except the one in 4.8ºE having antennas of 40 cm, so noise increase will be smaller for antenna size 45 cm than mentioned.

NOTE – Values of noise increase are taken from Annex 6, § 1.1.1 of this Report.

Study #2 calculates the pfd mask required to protect existing networks implementing earth stations with antenna size less than 0.60 m (40 cm and 45 cm).

Studies #1 and #2 show the necessity to develop protection measures (see § 11.3.2 of this Report) for implemented networks which are located in the allowable portions of the orbital arc 37.2°W-10°E with antenna sizes lower than 60 cm, from new possible network in previously forbidden arc portions, if the Annex 7 limitation "A3a" is deleted.

Study #3 provides an assessment of the existing levels of protection of receiving stations with small antennas, in particular antenna size of 40 cm and examines to what extent the current regulatory framework allows to implement networks, using antennas smaller than 60 cm, while maintaining the same level of protection $\Delta T/T$ = 6%, as defined by Annex 1 (section 1) by determining the level of interference and $\Delta T/T$ that may be currently caused by space stations (compliant with Annex 1 pfd mask) located in the adjacent allowable orbital arc positions.

Additional studies show that forbidden arc portions protect network with "small" antenna from allowed by Annex 1 interference at which $\Delta T/T$ = 6−41.27%, but the same levels of interference can be caused by networks located in allowable arc portions. Besides only part of forbidden arc portion

provides protection to "small" antenna, that compensates lower selectivity ranges, so part of the forbidden arc portion can be eliminated from the point of view of preserving the protection of the implemented[2] networks with "small" antennas from networks complying with Annex 1 pfd mask.

Thus, by itself, the presence of forbidden arc sections does not guarantee 6% interference level to earth stations with small antennas from networks complying with Annex 1 pfd mask.

Therefore, it cannot be claimed that forbidden arc portions always provide protection for a station with a "small" antenna, the presence of forbidden arc portions only reduces the probability of causing interference greater than 6% by networks in compliance with Section 1 Annex 1 pfd mask.

However, in conclusion study #3 determined that the network filed both in the allowable and forbidden portions of the orbital arc and being in compliance with Annex 1 pfd mask may cause interference to the earth station with 40 cm antenna resulting in $\Delta T/T$ up to 41.27% and such levels of interference must be accepted.

Due to the nature of the Section 1 Annex 1 pfd mask, only part of the forbidden arc portion provides protection from networks complying with this mask to networks with antenna sizes lower than 60 cm therefore part of the forbidden arc portion can be eliminated.

Study #4 shows possible implications to efficient protection of BSS satellite networks operating in this orbital arc with receiving earth station antennas of diameters smaller than 60 cm.

The current pfd protection masks that serve for the protection of Regions 1 and 3 planned BSS networks do not include the protection of receiving earth station antennas with diameters smaller than 60 cm. For example, between 2° and 5° of orbital separation the 45 cm receiving earth station antenna needs up to 7.2 dB bigger protection Therefore, in the case of revision or complete suppression of this limitation, currently implemented[3] receiving earth station antennas with diameters smaller than 60 cm might not be sufficiently protected.

Study #5 shows that for antenna sizes greater than or equal to 60 cm, the deletion of the Annex 7 limitation 'A3a' will not impact Regions 1 and 3 BSS networks located within the allowable portions of the orbital arc 37.2°W – 10°E for which the procedure of Article **4** has been completed or initiated, given that the pfd mask for intra-service sharing in BSS in Regions 1 and 3 (i.e. section 1 of Annex 1 of RR Appendix **30**), was developed for these antenna sizes.

Study #6 shows that the level of EPM/pfd degradation caused by Regions 1 and 3 networks located within the allowable portions of the orbital arc in accordance to Table 1 of Annex 7 to RR Appendix **30**, and for which the procedure of Article 4 of RR Appendix **30** would be initiated after the possible deletion of this limitation with respect to potential Region 1 BSS networks located within the forbidden arc according to Table 1 of Annex 7 of Appendix **30**, is lower than the degradation caused to Region 1 BSS networks located within the allowable portions of the orbital arc in accordance to Table 1 of Annex 7 to RR Appendix **30**.

Given the results of studies, limitation 'A3a' could be deleted, subject to additional measures ensuring the protection of, and without imposing additional constrains on, assignments in the Plan and in the List which are located in the allowable portion of the orbital arc 37.2°W – 10°E and including those which have antenna sizes lower than 60 cm.

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[2] See § 4.3.

[3] See § 4.3.

12 Annex 7 limitation ‘A3b’ (i.e. max. e.i.r.p. 56 dBW for assignments in the Regions 1 and 3 for specific positions in the frequency band 11.7-12.2 GHz)

12.1 Review of the limitation ‘A3b’

Section 3 of Annex 7 to RR Appendix **30** defines orbital position and e.i.r.p. limitations in the orbital arc 37.2°W-10°E, which were developed to preserve access to the geostationary-satellite orbit by the Region 2 fixed-satellite service in the frequency band 11.7-12.2 GHz.

This specific limitation (i.e. Annex 7 limitation “A3b”) states Region 1 BSS networks located within the allowable portion of the orbital arc 37.2°W-10°E but not coincident with any nominal orbital position in the Plan at the date of entry into force of the Final Acts of the 1977 Conference shall not transmit an e.i.r.p. greater than 56 dBW.

This constraint was historically developed as the Annex 7 limitation ‘A3a’ to protect Region 2 FSS networks. As for operational constraints, it is not always feasible to locate the Region 1 BSS network at the exact orbital position; it was decided to give some flexibility on the restricted orbital arc allowable in the orbital arc 37.2°W-10°E but in the same time to not put to many constraints into Region 2 FSS, it was decided to limit the power of these Region 1 BSS which are not located at the exact nominal orbital position.

Until the revision of the Annex 7 to RR Appendix **30** by the WRC-2000, networks located within this arc but not coincident with any nominal orbital position in the 1977 Plan were obliged to reduce their e.i.r.p. by 8 dB compared to that appearing in the Regions 1 and 3 Plan. WRC-2000 reviewed this strong constraint and decided to keep this concept but with less reduction and finally agreed to this 56 dBW limit.

TABLE 6

Portions of the orbital arc between 37.2°W and 10ºE for assignments in the Regions 1 and 3 List with Max. e.i.r.p. of 56 dBW

Orbital position with maximum e.i.r.p. of 56 dBW limitation
] 36.8°W ; 36°W]
] 33.5°W ; 32.5°W]
] 30°W ; 29°W]
[26°W ; 25.2°W [
] 24.8°W ; 24°W]
[20°W ; 19.2°W [
] 18.8°W ; 18°W]
[14°W ; 13.2°W [
] 12.8°W ; 12°W]
[8°W ; 7.2°W [
] 6.8°W ; 6°W]
[2°W ; 1.2°W [
] 0.8°W ; 0°E]
[4°E ; 4.8°E [
] 5.2°E ; 6°E]

12.2 Summary of sharing studies and results

As this reduction of e.i.r.p. was to only protect Region 2 FSS in addition of Annex 7 to RR Appendix **30** limitation 'A3a', studies performed under § 2 of Annex 6 and § 2 of Annex 1 of this Report are also applicable to this case.

Given the results of studies, the limitation 'A3b' could also be suppressed.

13 Annex 7 limitation 'A3c' (i.e. Max. pfd of −138 dB(W/(m^2 ·27 MHz))) in Region 2 by assignments in the Regions 1 and 3 List at 4°W and 9°E in the frequency band 11.7-12.2 GHz)

13.1 Review of the limitation 'A3c'

Orbital positions 4°W and 9°E were initially not coincident with any nominal orbital position in the Plan at the date of entry into force of the Final Acts of the 1977 Conference but were added by WRC-2000 during the replanning process following specific requests made by two Administrations. As compromised solution, WRC-2000 agreed these two specific requests subject to some additional protection measure over Region 2 to specifically protect Region 2 FSS networks.

13.2 Summary of sharing studies and results

As this specific pfd limit over Region 2 was to only protect Region 2 FSS for these two specific orbital positions, studies performed under § 2 of Annex 6 and § 2 of Annex 1 of this Report are also applicable to this case.

Given the results of studies, limitation 'A3c' could also be suppressed.

14 Annex 7 limitation 'B' (i.e. Region 2 cluster in the frequency band 12.2-12.7 GHz)

14.1 Review of the limitation B

The Region 2 BSS Plan is based on the grouping of the space stations in nominal orbital positions of ±0.2° from the centre of the cluster of satellites. Administrations may locate those satellites within a cluster at any orbital position within that cluster, provided they obtain the agreement of administrations having assignments to space stations in the same cluster.

This limitation is still used in BSS Region 2 Plan, therefore the limitation B shall be kept.

Annex 1

Studies on Annex 7 limitation 'A1a' (i.e. No assignments in the Region 1 List further west than 37.2°W in the frequency band 11.7-12.2 GHz)

1 Study#1: sharing between Region 1 BSS and Region 2 FSS networks in 11.7-12.2 GHz (Atlantic)

A determination was made of the orbital separation for various e.i.r.p. levels of representative BSS and FSS networks to meet the Annex 1 pfd masks. In addition, the *C*/*I* level for various orbital

separations within the Annex 7 arc using representative BSS and FSS network parameters was calculated.

1.1 Assumed parameters for Region 1 BSS and Region 2 FSS

TABLE A1-1

Assumed Region 1 BSS parameters

Type	DTH
Peak e.i.r.p., dBW	58/56
Transponder BW, MHz	27
Carrier BW, MHz	27
Peak e.i.r.p./carrier	58
EOC e.i.r.p./carrier	52
Receive earth station size, m	0.6
Receive earth station gain, dBi	35.7
Receive earth station antenna pattern	BO.1213

NOTE – The e.i.r.p. of any proposed new or modified assignment in the Regions 1 and 3 List of additional uses which lies within one of the portions of the orbital arc listed in Table 1 of Annex 7 to RR Appendix **30** shall not exceed 56 dBW, except at the positions listed in Table 2 of Annex 7 to RR Appendix **30**.

TABLE A1-2

Assumed Region 2 FSS parameters

Type	DTH	VSAT outbound	Point-to-point
Peak e.i.r.p. (dBW)	53	53	53
Transponder BW (MHz)	36	36	36
Carrier BW (MHz)	36	8	1.2
Peak e.i.r.p./carrier	53	42.5	34.2
EOC e.i.r.p./carrier	47	36.5	28.2
Receive earth station size (m)	0.75	1.2	4.5
Receive earth station gain (dBi)	37.6	41.7	53.2
Receive earth station antenna pattern	BO.1213	BO.1213	BO.1213

NOTE – Recommendation ITU-R BO.1213 intends to establish reference earth station co-polar and cross-polar antenna patterns for the broadcasting-satellite service (BSS) in the 11.7-12.75 GHz frequency band.

1.2 Results of analyses – Region 1 BSS into Region 2 FSS (section 6 of Annex 1 to RR Appendix 30)

The following Figure provides an assessment of the orbital separation where the representative BSS networks in Table A1-1 would meet Section 6 of Annex 1 to RR Appendix **30** coordination trigger levels. Given the geographic separation between Regions 1 and 2 and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 1 BSS networks are assumed.

FIGURE A1-1

Comparison of representative BSS pfd levels with those in section 6 of Annex 1 at 12 GHz

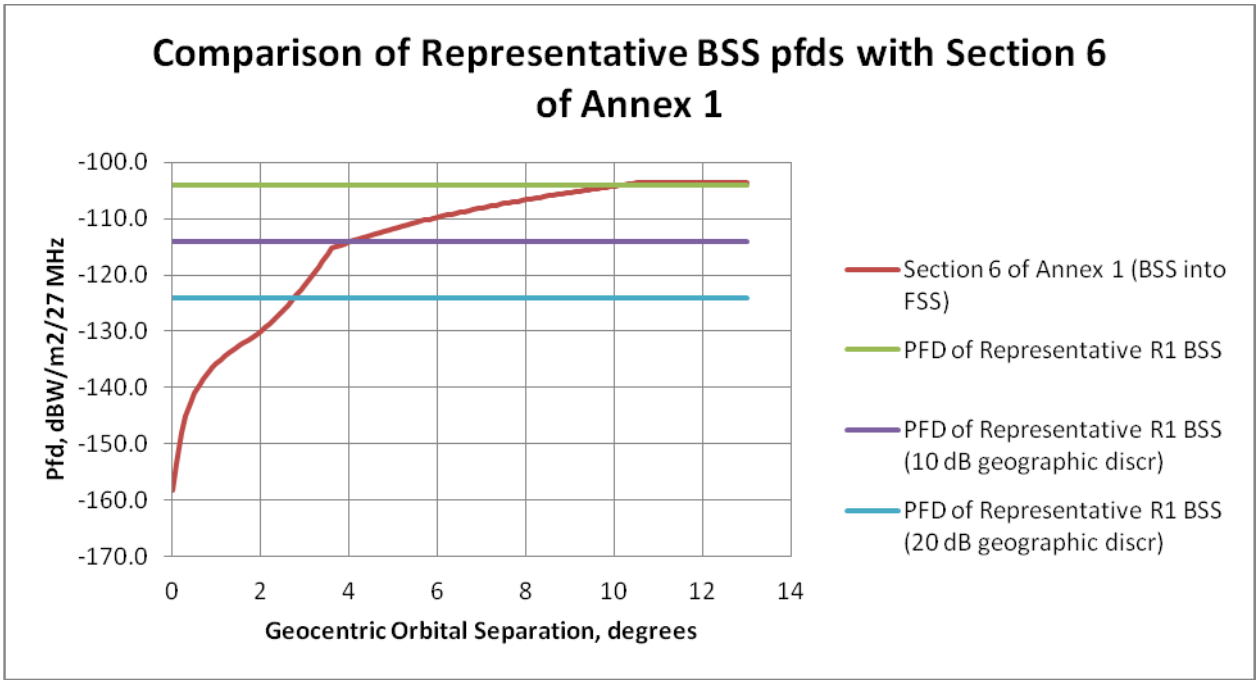


Figure A1-2, shows the resulting *C*/*I*s into the representative FSS parameters provided in Table A1-2 above, assuming a minimum of 10 dB of geographic discrimination from the Region 1 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak FSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A1-3 shows the resulting *C*/*I*s levels into the representative FSS parameters provided in Table A1-2 above assuming the maximum level from the Region 1 BSS according to section 6 of Annex 1 of Appendix **30**.

FIGURE A1-2

***C/I* levels into Region 2 FSS from representative Region 1 BSS with 10 dB geographic discrimination at 12 GHz**

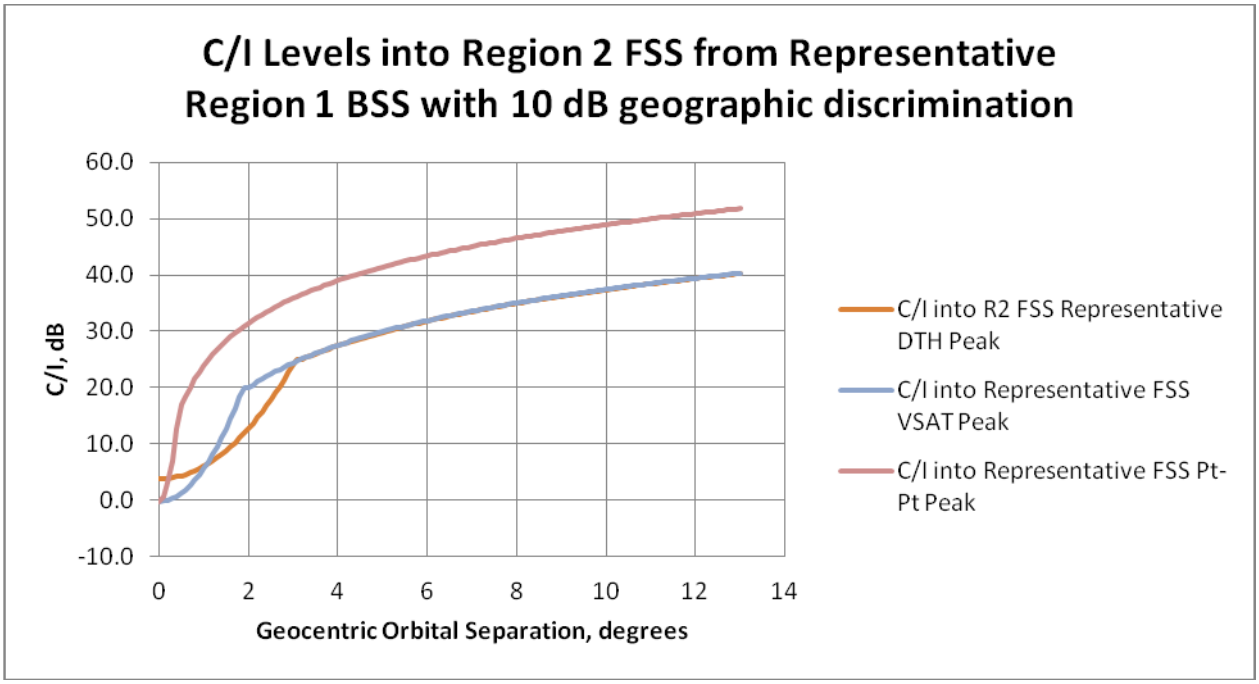
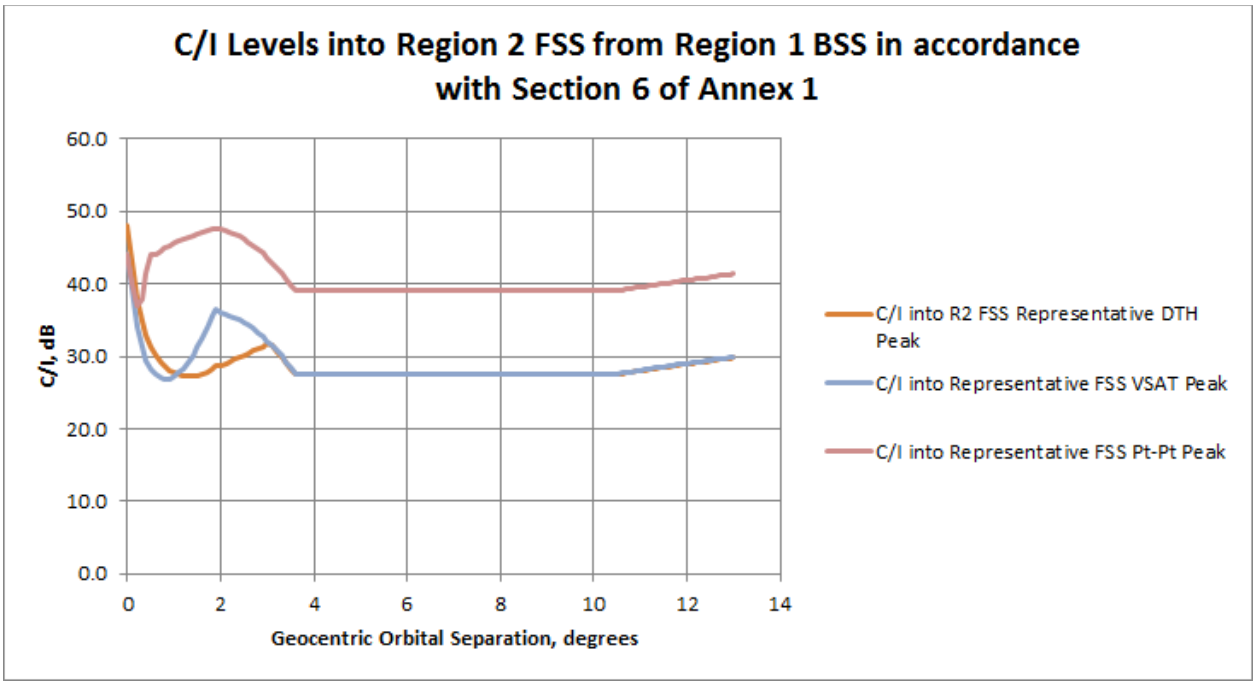


FIGURE A1-3

***C/I* levels into Region 2 FSS from Region 1 BSS in accordance with section 6 of Annex 1 of Appendix 30**



1.3 Results of analyses – Region 2 FSS into Region 1 BSS (Annex 4 to RR Appendix 30)

Figure A1-4 provides an assessment of the orbital separation assuming a geographic discrimination of 10 dB where the representative FSS networks in Table A1-2 would meet the Annex 4 to RR Appendix **30** coordination trigger levels. Varying levels of geographic discrimination of the Region 2 FSS networks could be assumed.

FIGURE A1-4

Comparison of representative FSS pfd levels with those in Annex 4 at 12 GHz

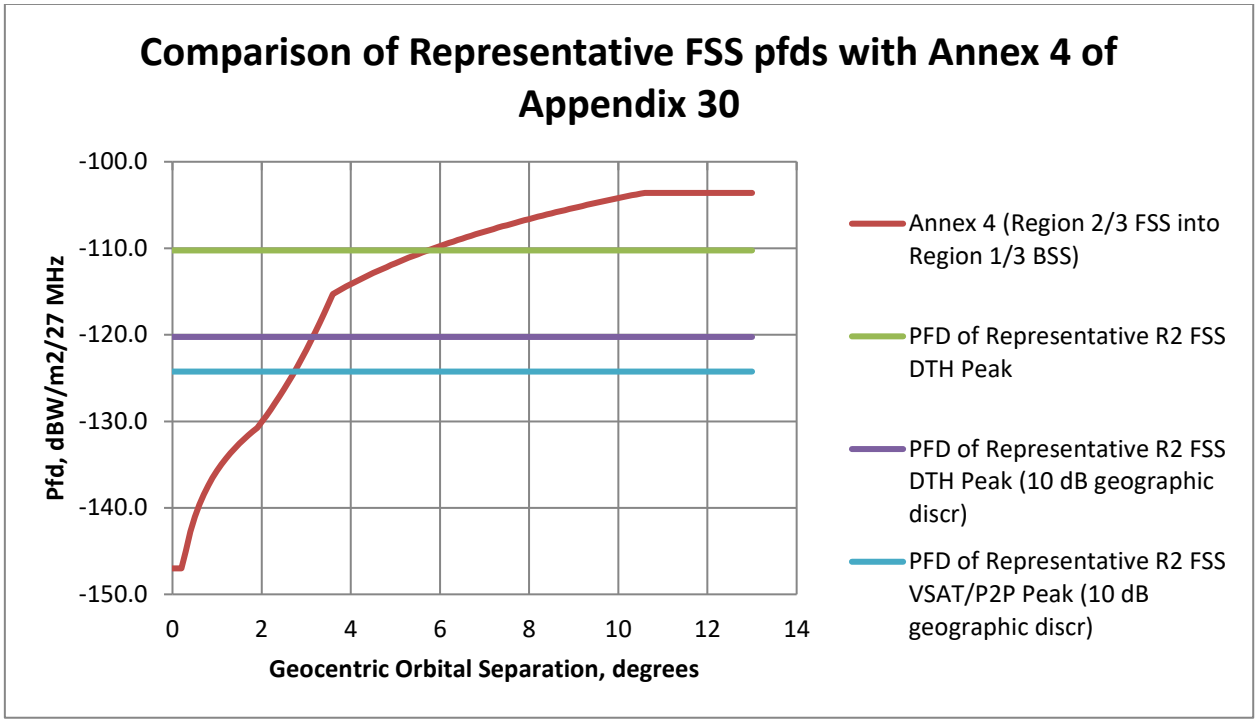


Figure A1-5 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A1-1 above, assuming a minimum of 10 dB of geographic discrimination from the Region 2 FSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A1-6 shows the resulting *C*/*Is* levels into the representative BSS parameters provided in Table A1-1 above assuming the maximum level from the Region 2 FSS according to Annex 4 of Appendix **30**.

FIGURE A1-5

***C/I* levels into Region 1 BSS from representative Region 2 FSS at 12 GHz**

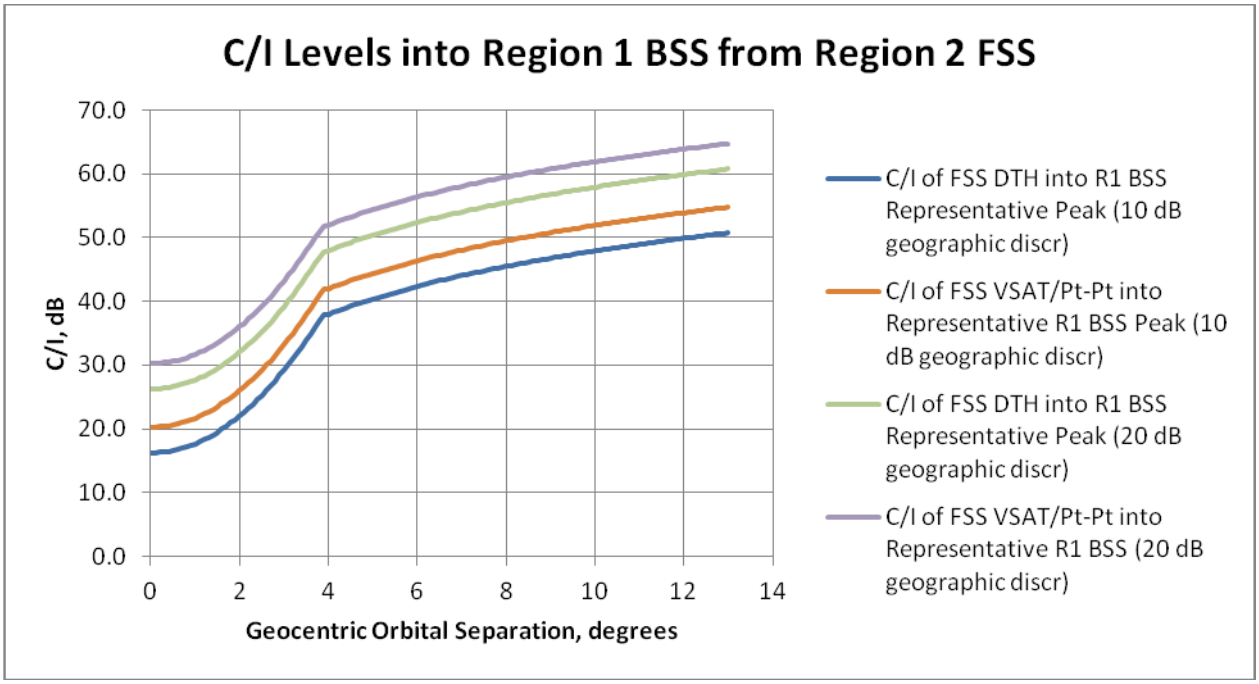
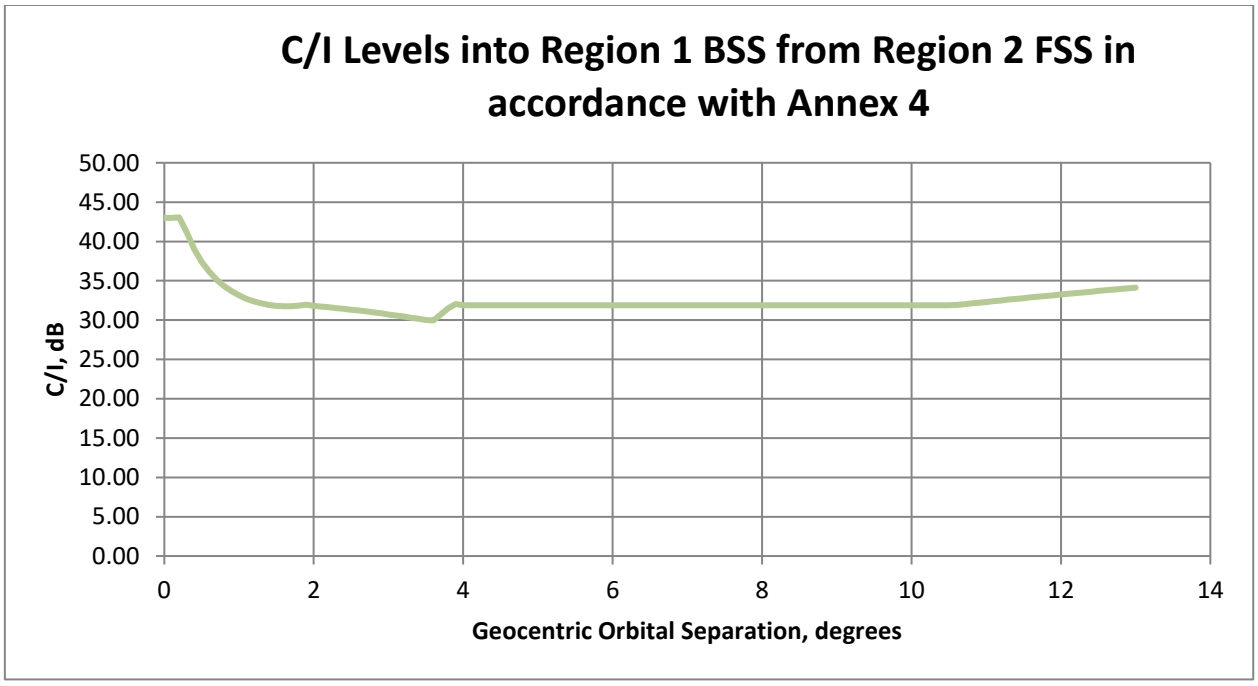


FIGURE A1-6

***C/I* levels into Region 1 BSS from Region 2 FSS in accordance with Annex 4 of Appendix 30**



The above results show the following orbital separations are needed to avoid triggering coordination between Region 1 BSS networks and Region 2 FSS networks in the 11.7-12.2 GHz frequency band.

TABLE A1-3

Results of analysis for orbital separations to avoid triggering coordination between Region 1 BSS and Region 2 FSS in 11.7-12.2 GHz

BSS → FSS (section 6 of Annex 1 to AP 30)

	Peak			**EOC**		
e.i.r.p. density of interfering network (dBW/MHz)	43.7	43.7	43.7	37.7	37.7	37.7
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	-10.0	–20.0	0.0	-10.0	-20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–104.0	–114.0	–124.0	–110.0	–120.0	–130.0
Orbital separation to meet AP **30** levels (degree)	10.1	4.0	2.7	5.8	3.1	2.0

FSS → BSS (Annex 4 to AP 30)

	Peak			**EOC**		
Type of FSS link	DTH	VSAT outbound	Point-to-point	DTH	VSAT outbound	Point-to-point
e.i.r.p. density of interfering network (dBW/MHz)	37.4	33.4	33.4	31.4	27.4	27.4
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	–0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–110.2	–124.2	–134.2	–116.2	–130.2	–140.2
Orbital separation to meet AP **30** levels (degree)	5.7	2.7	1.2	3.5	1.9	0.5

2 Study #2: Technical analyses of orbital arcs around limiting orbital positions of BSS in Region 1

In order to analyse the feasibility of such orbital arc extension, additional technical analyses were done. These analyses show necessary additional discrimination that would be needed by BSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable. Similar analyses were done in all other sharing situations covered in this Report.

Assumed parameters of representative Region 1 BSS networks and Region 2 FSS networks that were taken into account in the analyses are presented in Tables A1-4 and A1-5.

TABLE A1-4

Representative Region 1 BSS network parameters

Type of service/carriers	DTH	DTH	DTH	DTH	DTH
Peak e.i.r.p. (dBW)	58.9	56.9	55.9	53.9	53.9
Channel bandwidth (MHz)	33	33	33	33	33
Peak e.i.r.p. in 27 MHz (dBW)	58	56	55	53	53
RX earth station antenna (m)	0.6	0.6	0.6	0.9	1.2
RX earth station gain (dBi)	35.5	35.5	35.5	39.0	41.5
RX earth station rad. pattern	BO.1213	BO.213	BO.1213	BO.1213	BO.1213

Representative peak e.i.r.p. values for western part of the orbital arc under study were 56 and 53 dBW/ 27 MHz, taking into account the current e.i.r.p. limitations contained in Annex 7 to Appendix **30**. The peak e.i.r.p. values taken into account for the eastern part of the studied orbital arc in Region 1 were 55 and 58 dBW / 27 MHz.

TABLE A1-5

Representative FSS network parameters

Type of service/carriers	DTH	VSAT outbound	VSAT inbound
Peak e.i.r.p. (dBW)	53	53	53
Channel Bandwidth (MHz)	36	36	36
Carrier Bandwidth (MHz)	36	8	1.2
Peak e.i.r.p. per carrier (dBW)	53	42.5	34.2
Peak e.i.r.p. in 27 MHz (dBW)	51.8	47.8	47.7
RX earth station antenna (m)	0.75	1.2	4.5
RX earth station gain (dBi)	37.4	41.5	53.0
RX earth station rad. pattern	BO.1213	BO.1213	S.580

Peak e.i.r.p.s taken into account reflect the standard e.i.r.p. applied for a new BSS filing, as well as usual e.i.r.p. peak value of BSS networks already included into the Appendix **30** BSS List.

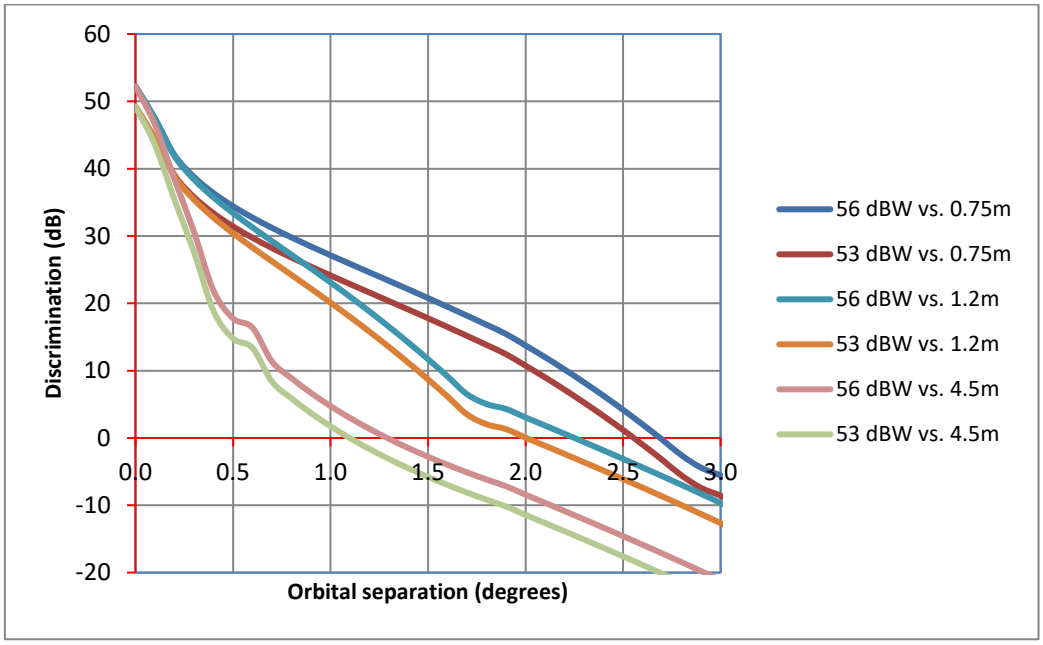
BSS receiving earth station antennas of 60, 90 and 120 cm were assumed in these studies, reflecting the antenna diameters of the BSS networks that are contained in the BSS List and have already been notified.

The results of analysis between Region 1 interfering BSS networks and Region 2 victim FSS networks are shown in Fig. A1-7 for the orbital arc around 37.2°W.

As the needed discrimination is positive only for orbital separation smaller than 3 degrees, only this part of results is shown in Fig. A1-7.

FIGURE A1-7

Needed discrimination for the Region 1 BSS around 37.2°W vs. Region 2 FSS case



For the case of western limiting orbital position 37.2°W it is visible that for all applied peak e.i.r.p. values of Region 1 BSS networks and Region 2 FSS receiving earth station antenna diameters in Table A1-5, no additional discrimination is needed for orbital separations bigger than 2.7° in order to overcome coordination problems.

With 10 dB of discrimination these values are in the range between 0.7° and 2.2°, depending on the combination of interfering e.i.r.p. and earth station receiving antenna diameter. With 20 dB of discrimination these values are in the range to 0.4° to 1.6°.

This shows that possible coordination scenarios between BSS networks in Region 1 and FSS networks in Region 2 are favourable if it exists sufficient geographical discrimination between FSS and BSS networks.

In the opposite case of sharing scenario (Region 2 FSS network versus Region 1 BSS network) the feasibility of such orbital arc extension was analysed to show necessary additional discrimination needed to be applied by FSS networks in this extended orbital arc in order to indicate easily resolvable coordination cases.

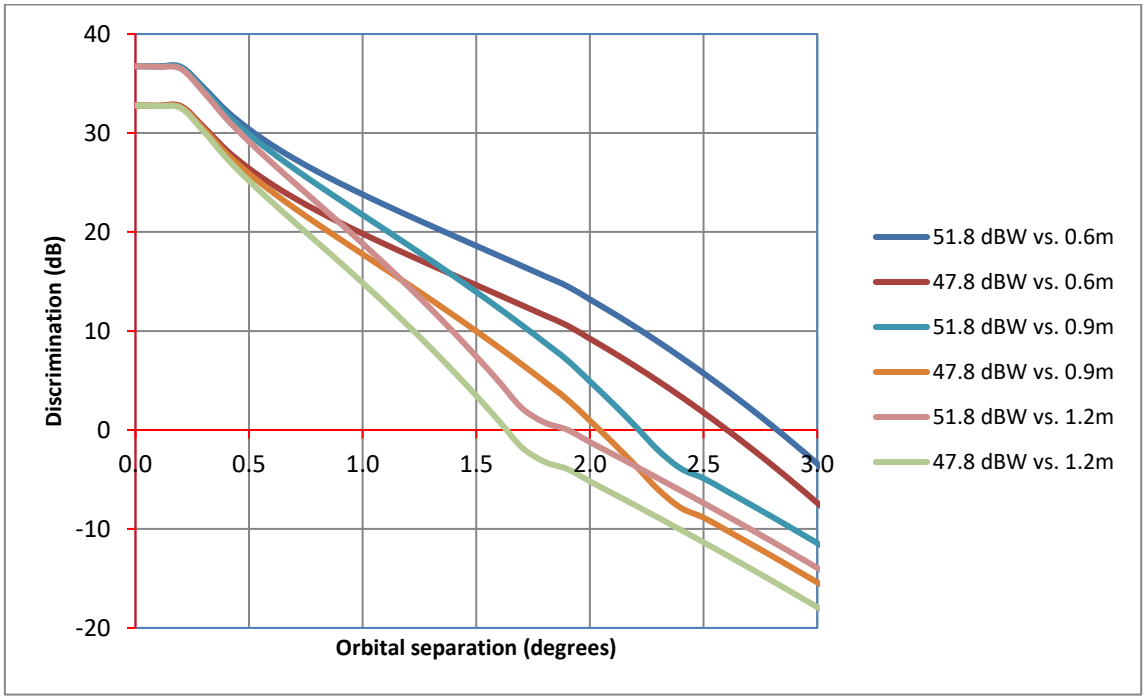
In this case the situation is even better due to the fact that unplanned FSS networks usually employ lower peak e.i.r.p. values, compared to planned BSS networks. On the other side, the protection of smaller BSS receiving earth station antennas makes the sharing situation a bit more difficult.

The results of analysis are shown in Fig. A1-13 for the orbital arc around 37.2°W.

As the needed discrimination is positive only for orbital separations smaller than 3 degrees only this part of results is shown in Fig. A1-8.

FIGURE A1-8

Needed discrimination for the Region 2 FSS around 37.2ºW vs. Region 1 BSS case



For the case of western limiting orbital position 37.2°W, from Fig. A1-8 it is visible that for all applied peak e.i.r.p. values of Region 2 FSS networks and Region 1 BSS representative receiving earth station antenna diameters no additional discrimination is needed for orbital separations bigger than 2.8° in order to overcome coordination problems.

With 10 dB of discrimination these values are in the range between 1.2° and 2.2°, depending on the combination of interfering e.i.r.p. and earth station receiving antenna diameter. With 20 dB of discrimination these values are in the range to 0.7° to 1.3°.

This shows that possible coordination scenarios between FSS networks in Region 2 and BSS networks operating in Region 1 are also favourable if it exists sufficient geographical discrimination between FSS and BSS networks.

Annex 2

Studies on Annex 7 limitation ‘A1b’ (i.e. no assignments in the Region 1 List further east than 146°E in the frequency band 11.7-12.2 GHz)

1 Study #1: Sharing study between Region 1 BSS and Region 2 FSS networks in 11.7-12.2 GHz (Pacific)

A determination is made of the orbital separation for various e.i.r.p. levels of representative BSS and FSS networks to meet the Annex 1 and/or Annex 4 pfd masks. In addition, the *C*/*I* level is calculated for various orbital separations within the Annex 7 arc using representative BSS and FSS network parameters.

1.1 Assumed parameters for Region 1 BSS and Region 2 FSS

The parameters provided in Annex 1, § 1.1 above are used.

1.2 Results of analyses – Region 1 BSS into Region 2 FSS (section 6 of Annex 1 to RR Appendix 30)

Figure A2-1 provides an assessment of the orbital separation where the representative BSS network in Table A2-1 would meet section 6 of Annex 1 to RR Appendix **30** coordination trigger levels. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 1 BSS network are assumed.

FIGURE A2-1

Comparison of representative BSS pfd levels with those in section 6 of Annex 1 at 12 GHz

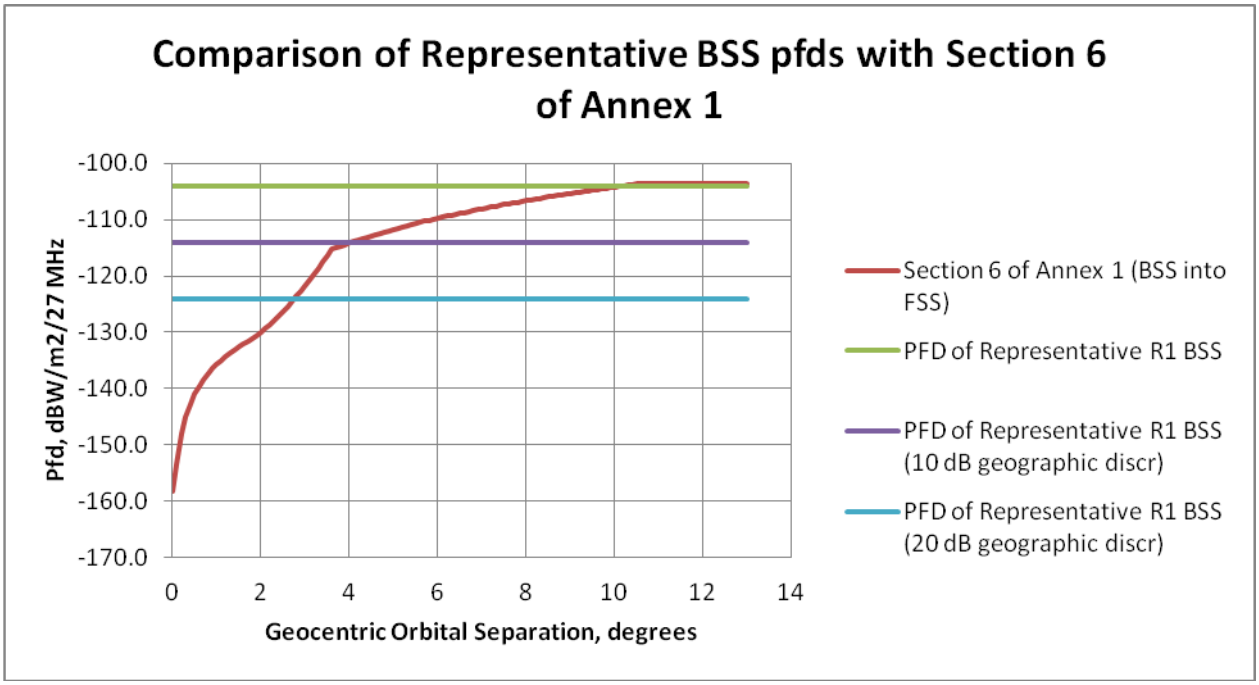


Figure A2-2 shows the resulting *C*/*I*s into the representative FSS parameters provided in Table A1-2 above, assuming a minimum of 10 dB of geographic discrimination from the Region 1 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak FSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A2-9 shows the resulting *C*/*I*s levels into the representative FSS parameters provided in Table A1-2 above assuming the maximum level from the Region 1 BSS according to section 6 of Annex 1 of Appendix **30**.

FIGURE A2-2

***C/I* levels into Region 2 FSS from representative Region 1 BSS with 10 dB geographic discrimination at 12 GHz**

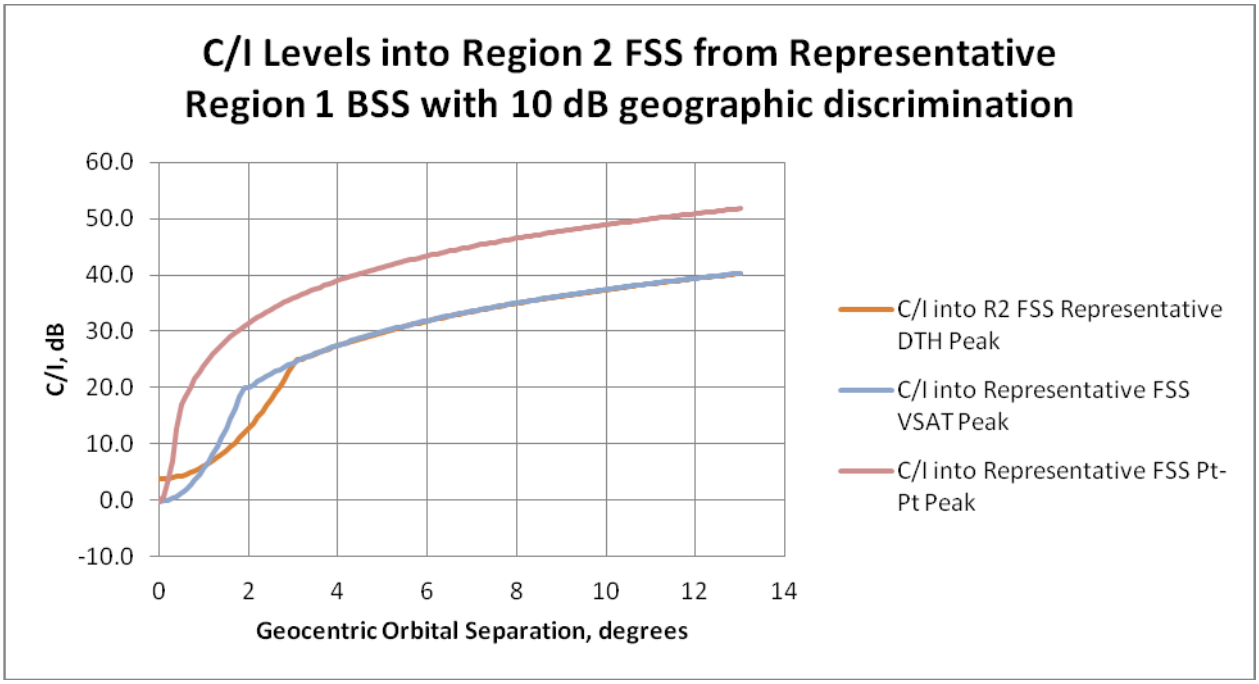
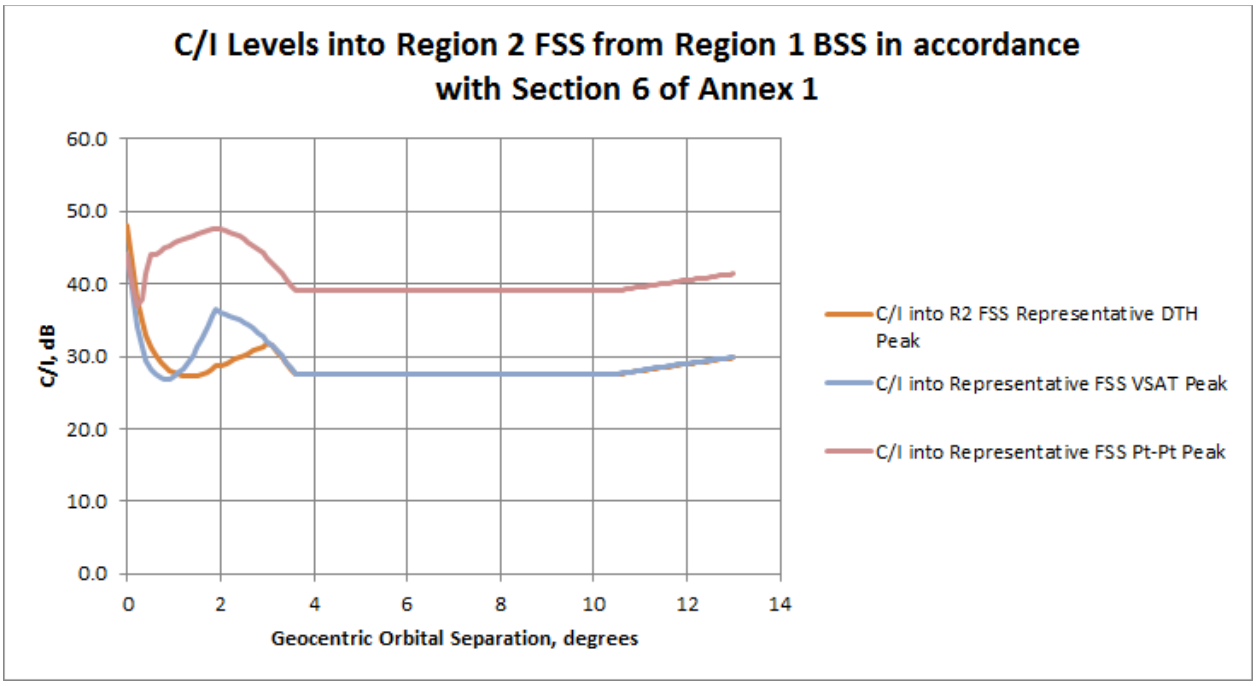


FIGURE A2-3

***C/I* levels into Region 2 FSS from Region 1 BSS in accordance with section 6 of Annex 1 of Appendix 30**



1.3 Results of analyses – Region 2 FSS into Region 1 BSS (Annex 4 to RR Appendix 30)

Figure A2-4 provides an assessment of the orbital separation assuming a geographic discrimination of 10 dB where the representative FSS networks in Table A1-2 would meet the Annex 4 to RR Appendix **30** coordination trigger levels. Varying levels of geographic discrimination of the Region 2 FSS networks could be assumed.

FIGURE A2-4

Comparison of representative FSS pfd levels with those in Annex 4 at 12 GHz

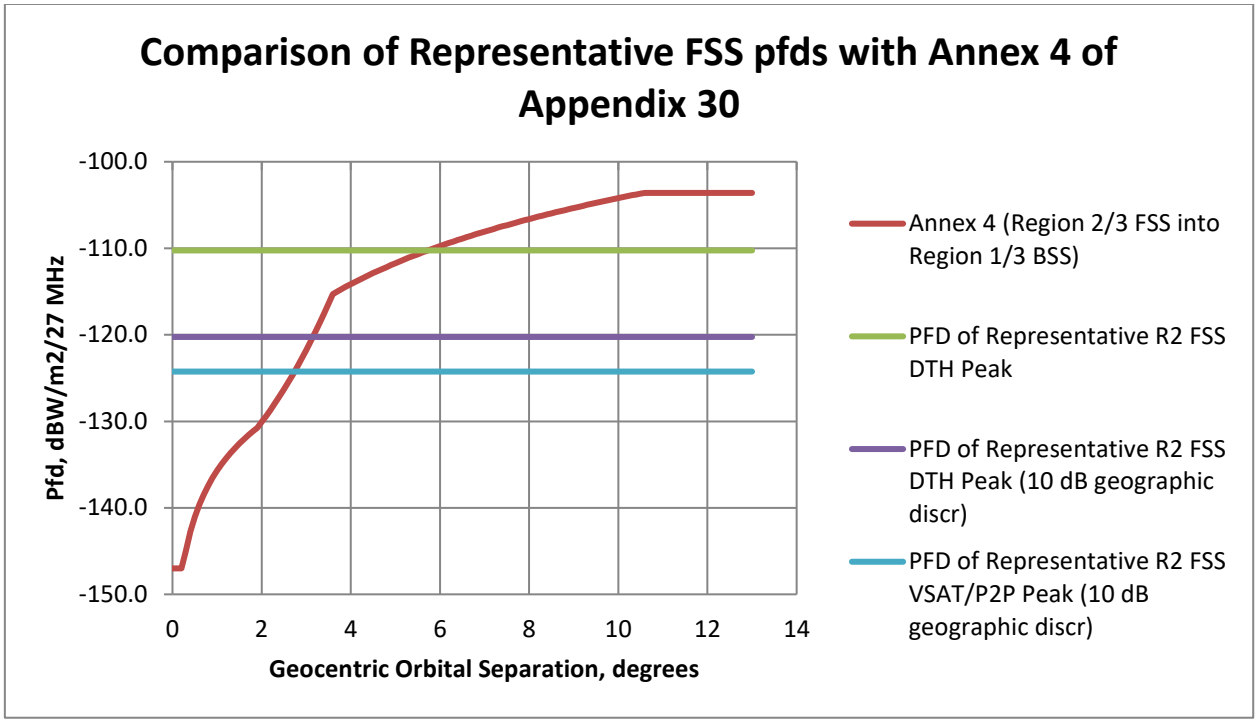


Figure A2-5 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A1-1 above, assuming a minimum of 10 dB of geographic discrimination from the Region 2 FSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A2-6 shows the resulting *C*/*I*s levels into the representative BSS parameters provided in Table A1-1 above assuming the maximum level from the Region 2 FSS according to Annex 4 of Appendix **30**.

FIGURE A2-5

***C/I* levels into Region 1 BSS from representative Region 2 FSS at 12 GHz**

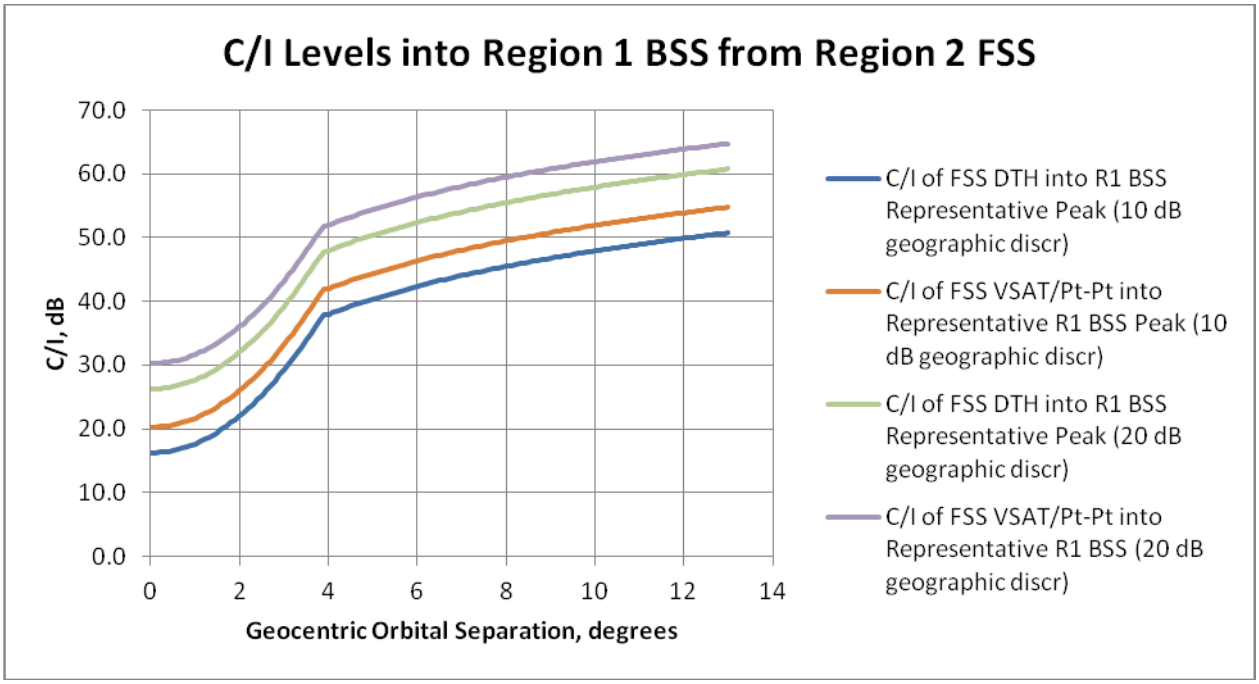
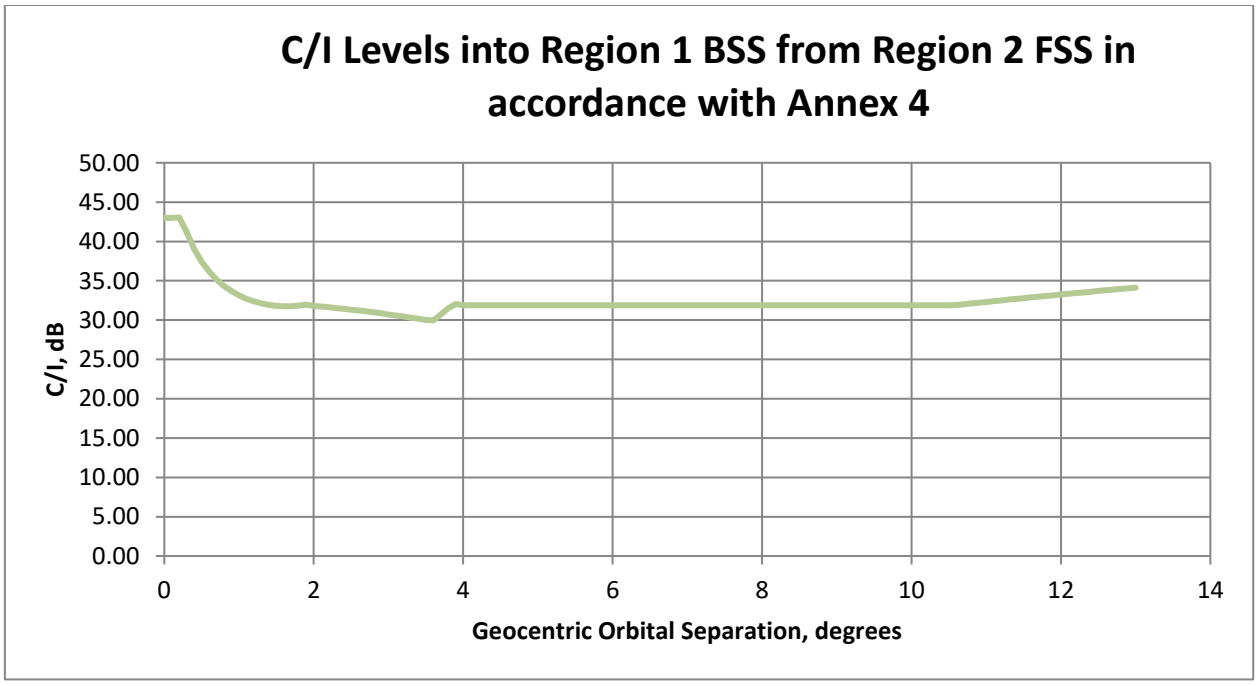


FIGURE A2-6

***C/I* levels into Region 1 BSS from Region 2 FSS in accordance with Annex 4 of Appendix 30**



The above results show the following orbital separations are needed to avoid triggering coordination between Region 1 BSS networks and Region 2 FSS networks in the 11.7-12.2 GHz frequency band.

TABLE A2-1

Results of analysis for orbital separations to avoid triggering coordination between Region 1 BSS and Region 2 FSS in 11.7-12.2 GHz

BSS → FSS (section 6 of Annex 1 to AP 30)

	Peak			**EOC**		
e.i.r.p. density of interfering network (dBW/MHz)	43.7	43.7	43.7	37.7	37.7	37.7
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–104.0	–114.0	–124.0	–110.0	–120.0	–130.0
Orbital separation to meet AP **30** levels (degree)	10.1	4.0	2.7	5.8	3.1	2.0

FSS → BSS (Annex 4 to AP 30)

	Peak			**EOC**		
Type of FSS link	DTH	VSAT out bound	Point-to-point	DTH	VSAT out bound	Point-to-point
e.i.r.p. density of interfering network (dBW/MHz)	37.4	33.4	33.4	31.4	27.4	27.4
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–110.2	–124.2	–134.2	–116.2	–130.2	–140.2
Orbital separation to meet AP **30** levels (degree)	5.7	2.7	1.2	3.5	1.9	0.5

2 Study #2: Technical analyses of orbital arcs around limiting orbital positions of BSS in Region 1

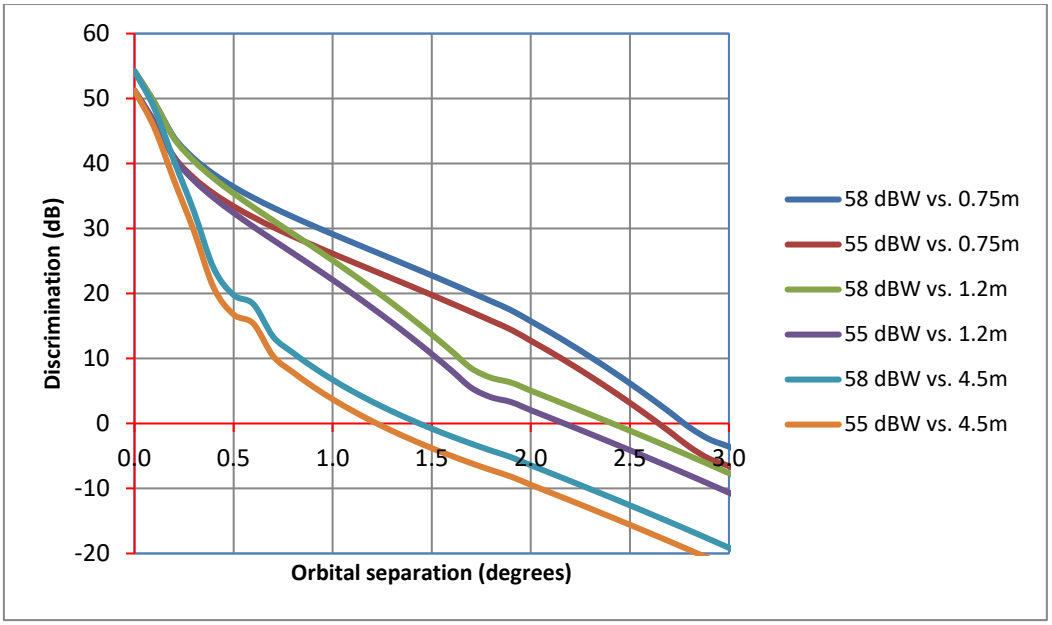
The results of analysis between Region 1 interfering BSS networks and Region 2 victim FSS networks are shown in Fig. A2-7 for the orbital arc around 146°E.

As the needed discrimination is positive only for orbital separation smaller than 3 degrees, only this part of results is shown in Fig. A2-7.

For the case of eastern limiting orbital position 146°E it is visible from Fig. A2-7 that for all applied peak e.i.r.p. values of Region 1 BSS networks and Region 2 FSS representative receiving earth station antenna diameters no additional discrimination is needed for orbital separations bigger than 2.8° in order to overcome coordination problems.

FIGURE A2-7

Needed discrimination for the Region 1 BSS around 146ºE vs. Region 2 FSS case



With 10 dB of discrimination these values are in range between 0.7° and 2.3°, depending on the combination of interfering e.i.r.p. and earth station receiving antenna diameter. With 20 dB of discrimination these values are in the range to 0.4° to 1.7°.

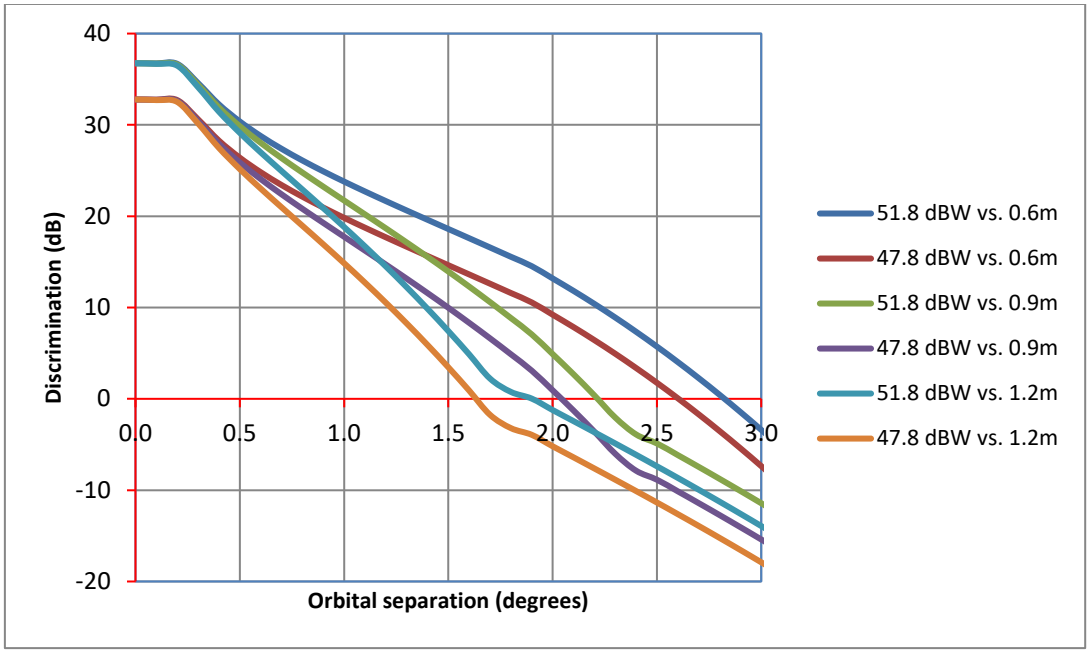
In the opposite case of sharing scenario (Region 2 FSS network vs. Region 1 BSS network) the results of analysis are shown in Fig. A2-8 for the orbital arc around 146°E.

As the needed discrimination is positive only for orbital separations smaller than 3 degrees only this part of results is shown in Fig. A2-8.

By applying 20 dB of discrimination, which could be difficult to achieve, the coordination problem would be minimal for orbital separations larger than 1°, except in the cases of maximum peak e.i.r.p. applied for FSS networks against BSS networks with smaller earth station antenna diameters.

FIGURE A2-8

Needed discrimination for the Region 2 FSS around 146ºE vs. Region 1 BSS case



Annex 3

Studies on Annex 7 limitation 'A2a' (i.e. no modifications in the Region 2 Plan further east than 54°W in the frequency band 12.5-12.7 GHz)

1 Study#1: sharing between Region 2 BSS and Region 1 FSS networks in 12.5-12.7 GHz (Atlantic)

A determination is made of the orbital separation for various e.i.r.p. levels of representative BSS and FSS networks to meet the Annex 1 and/or Annex 4 pfd masks. In addition, the *C*/*I* level is calculated for various orbital separations within the Annex 7 arc using representative BSS and FSS network parameters.

1.1 Assumed parameters for Region 2 BSS and Region 1 FSS

TABLE A3-1

Assumed Region 2 BSS parameters

Type	DTH
Peak e.i.r.p. (dBW)	57
Transponder BW (MHz)	24
Carrier BW (MHz)	24
Peak e.i.r.p./carrier (dBW)	57
Peak e.i.r.p. density (dBW/MHz)	43.2
EOC e.i.r.p./carrier (dBW)	51
EOC e.i.r.p. density (dBW/MHz)	37.2
Receive earth station size (m)	0.45, 1

TABLE A3-2

Assumed Region 1 FSS parameters

Type	DTH	VSAT outbound	Point-to-point
Peak e.i.r.p. (dBW)	53	53	53
Transponder BW (MHz)	36	36	36
Carrier BW (MHz)	36	8	1.2
Peak e.i.r.p./carrier	53	42.5	34.2
EOC e.i.r.p./carrier	47	36.5	28.2
Receive earth station size (m)	0.75	1.2	4.5
Receive earth station gain (dBi)	37.6	41.7	53.2
Receive earth station antenna pattern	BO.1213	BO.1213	BO.1213

NOTE – Recommendation ITU-R BO.1213 intends to establish reference earth station co-polar and cross-polar antenna patterns for the broadcasting-satellite service (BSS) in the 11.7-12.75 GHz frequency band.

1.2 Results of analyses – Region 2 BSS into Region 1 FSS (section 6 of Annex 1 to RR Appendix 30)

Figure A3-1 provides an assessment of the orbital separation where the representative BSS network in Table A3-1 would meet the section 6 of Annex 1 to RR Appendix **30** coordination trigger levels. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 2 BSS network are assumed.

FIGURE A3-1

Comparison of representative BSS pfd levels with those in section 6 of Annex 1 at 12.5 GHz

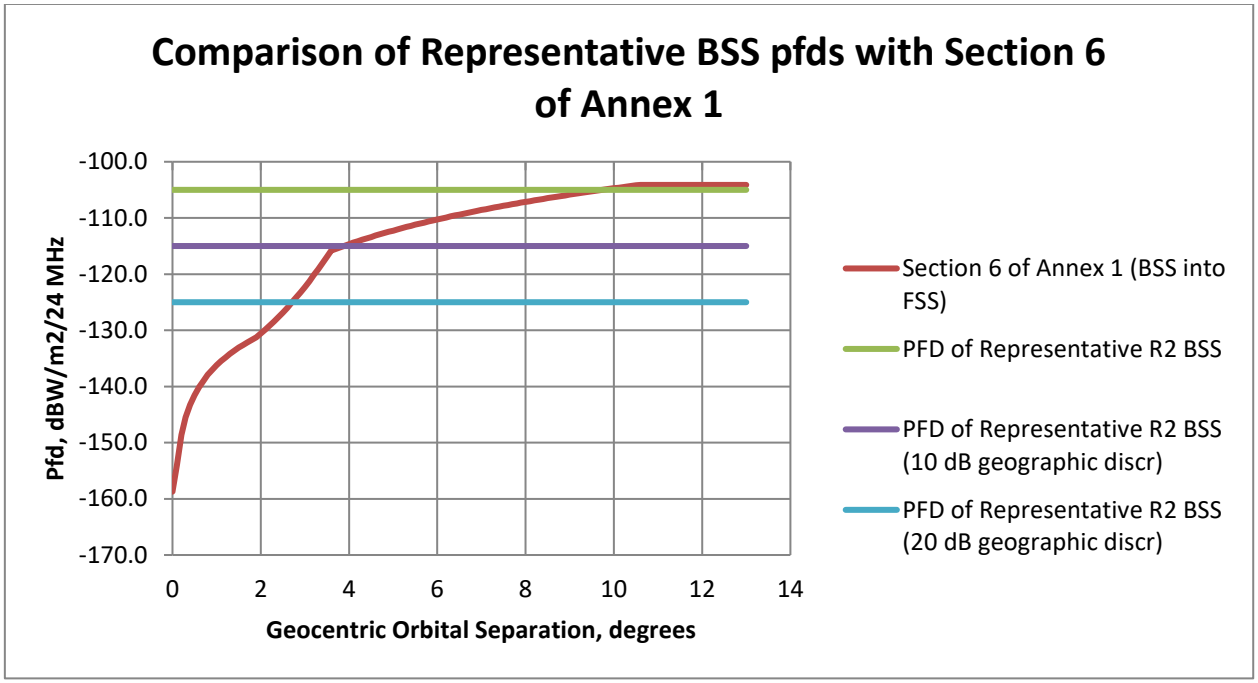


Figure A3-2 shows the resulting *C*/*I*s into the representative FSS parameters provided in Table A3-2, assuming a minimum of 10 dB of geographic discrimination from the Region 2 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak FSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A3-3 shows the resulting *C*/*Is* levels into the representative FSS parameters provided in Table A3-2 above assuming the maximum level from the Region 2 BSS according to section 6 of Annex 1 of Appendix **30**.

FIGURE A3-2

***C/I* levels into Region 1 FSS from representative Region 2 BSS with 10 dB geographic discrimination at 12.5 GHz**

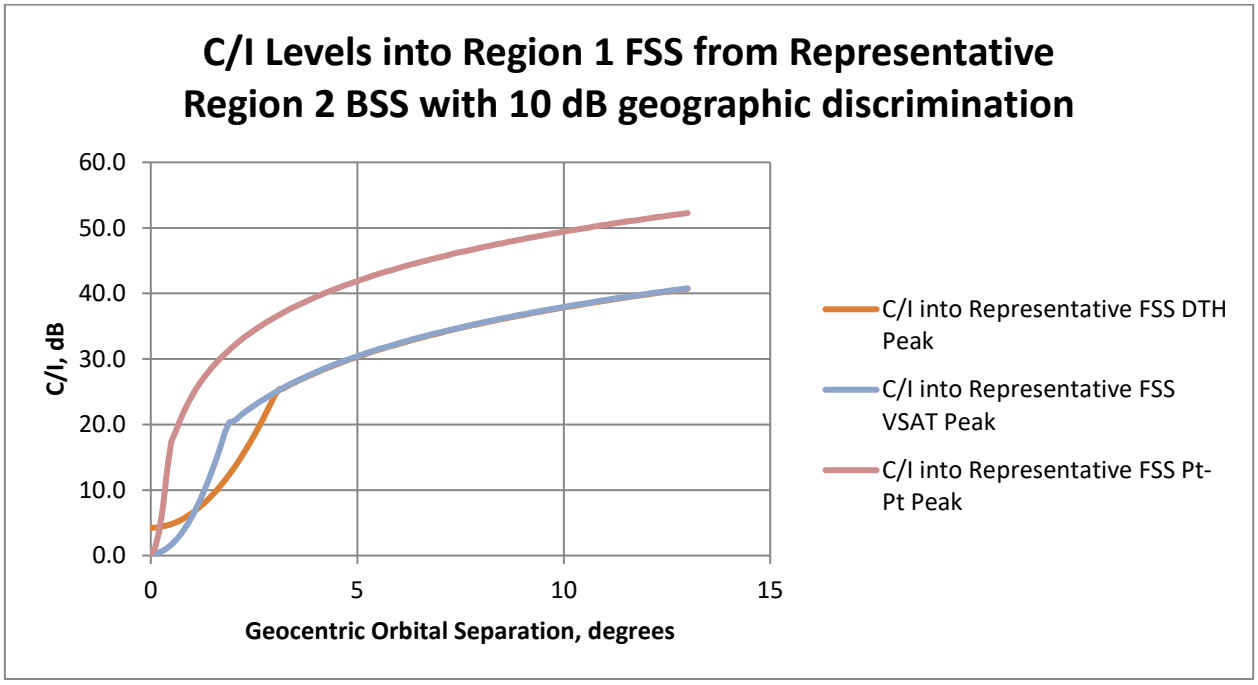
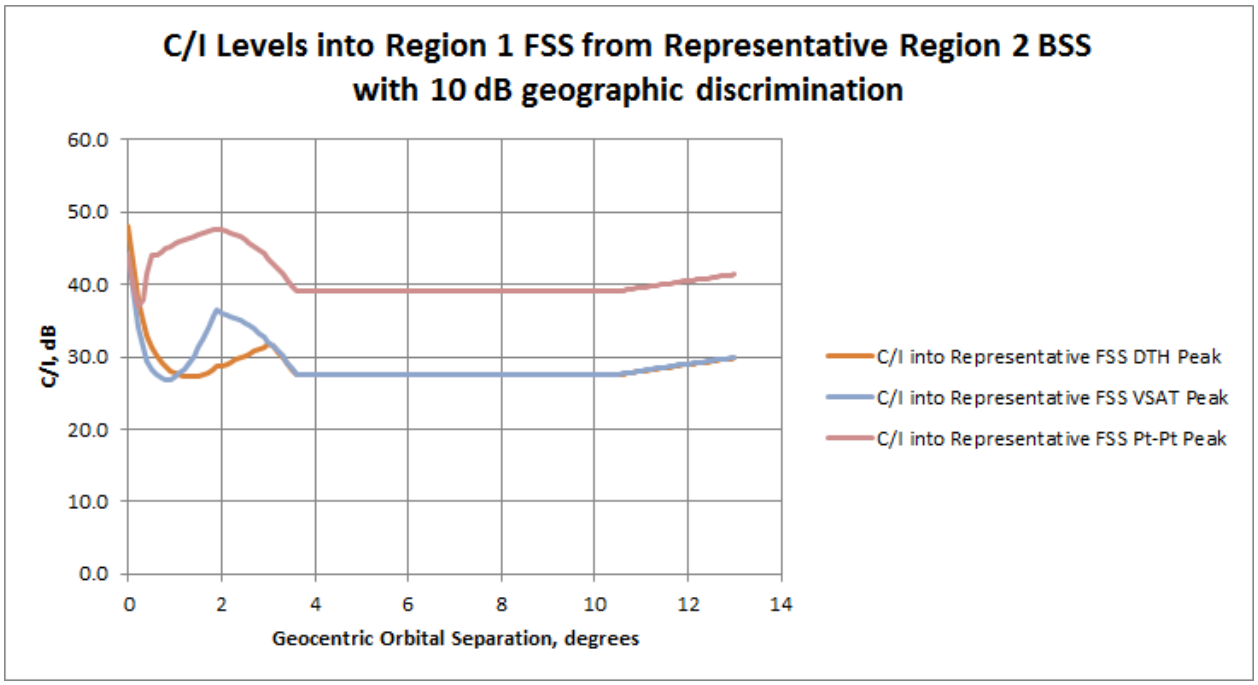


FIGURE A3-3

***C/I* levels into Region 1 FSS from Region 2 BSS in accordance with section 6 of Annex 1 of Appendix 30**



1.3 Results of analyses – Region 1 FSS into Region 2 BSS (Annex 4 to RR Appendix 30)

Figure A3-4 provides an assessment of the orbital separation assuming a geographic discrimination of 10 dB where the representative FSS networks in Table A3-2 would meet the Annex 4 to RR Appendix **30** coordination trigger levels. Varying levels of geographic discrimination of the Region 1 FSS networks could be assumed.

FIGURE A3-4

Comparison of representative FSS pfd levels with those in Annex 4 at 12.5 GHz

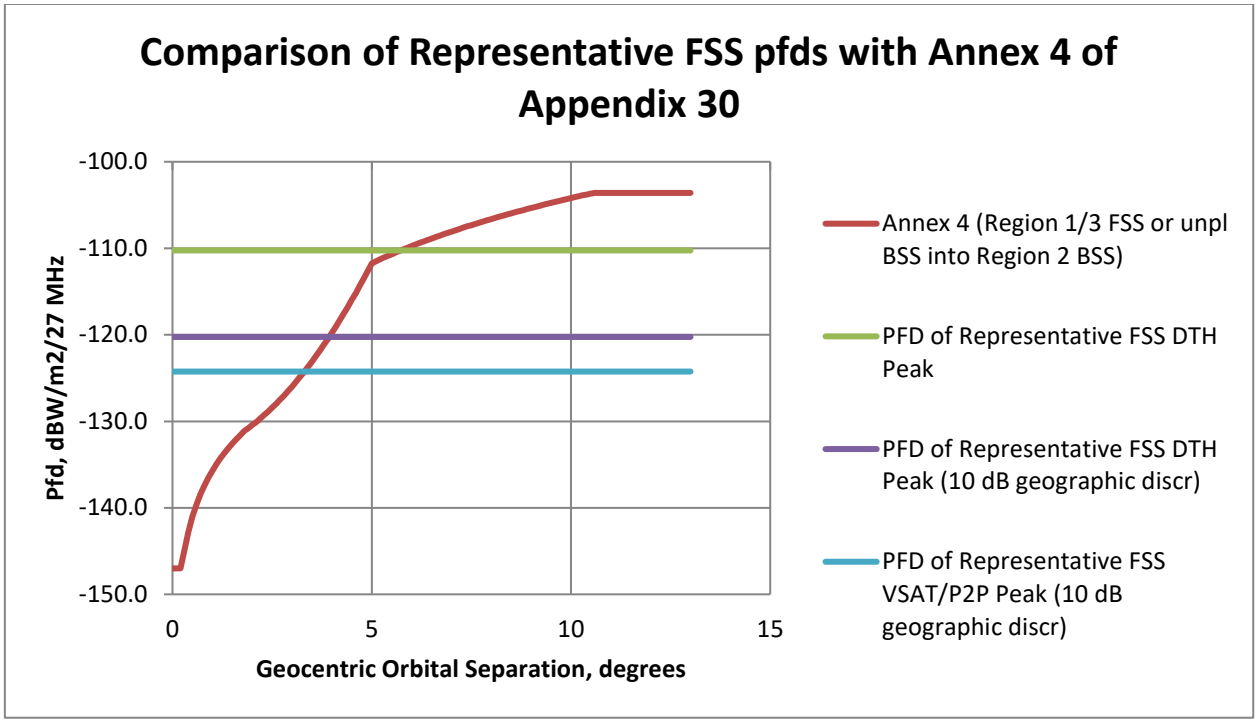


Figure A3-5 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A3-1 assuming a minimum of 10 dB of geographic discrimination from the Region 1 FSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A3-8 shows the resulting *C*/*I*s levels into the representative BSS parameters provided in Table A3-1 above assuming the maximum level from the Region 1 FSS according to Annex 4 of Appendix **30**.

FIGURE A3-5

***C/I* levels into Region 2 BSS from representative Region 1 FSS at 12.5 GHz**

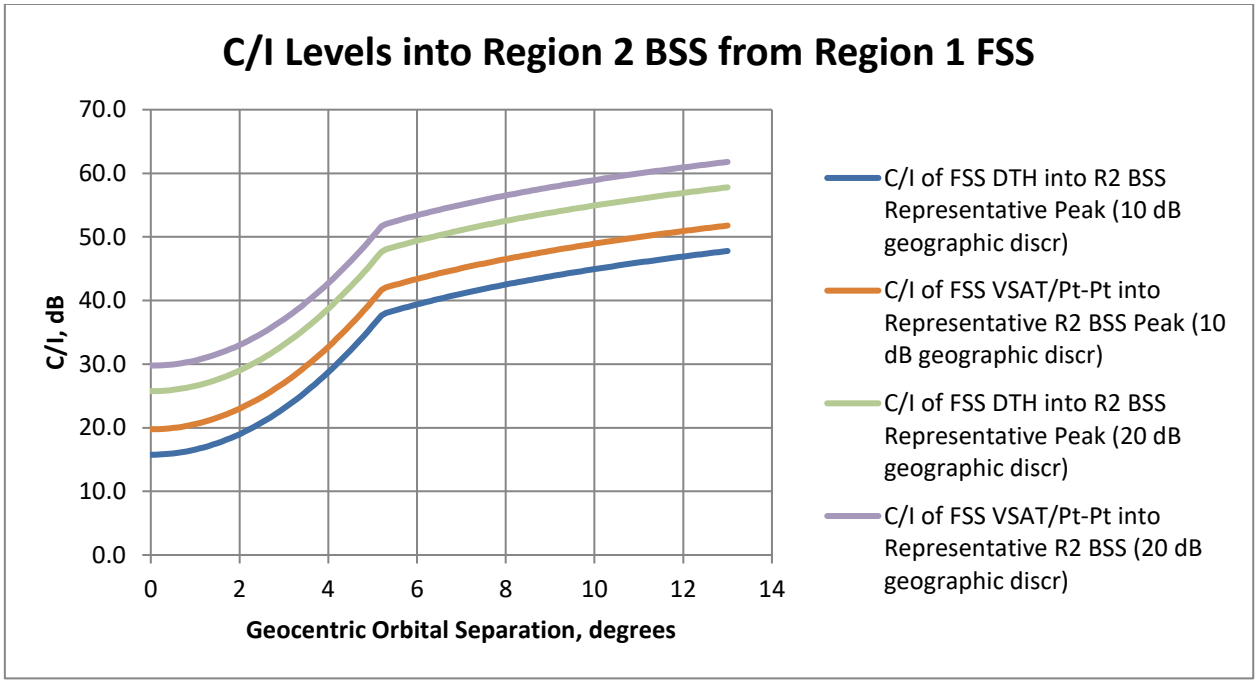


FIGURE A3-6

***C/I* levels into Region 2 BSS from Region 1 FSS in accordance with Annex 4 of Appendix 30**

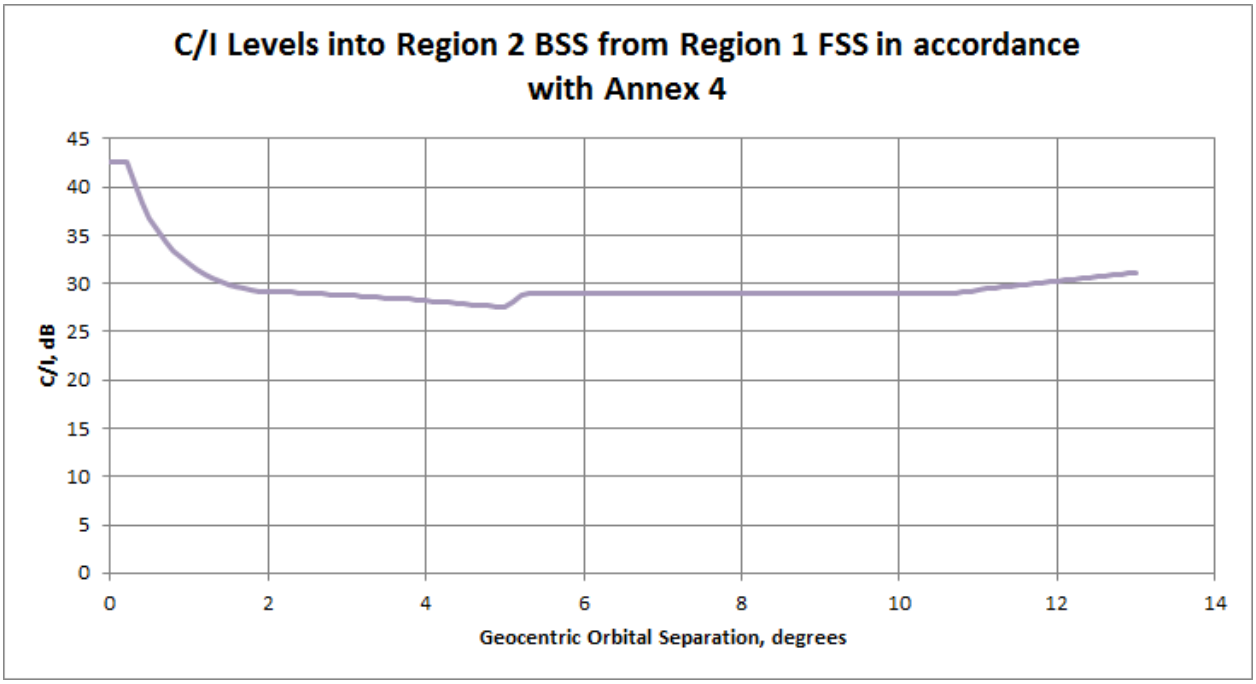


TABLE A3-3

Results of analysis orbital separations to avoid triggering coordination between Region 2 BSS and Region 1 FSS in 12.5-12.7 GHz

BSS → FSS (section 6 of Annex 1 to AP 30)

	Peak			**EOC**		
e.i.r.p. density of interfering network (dBW/MHz)	43.2	43.2	43.2	37.2	37.2	37.2
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 24 MHz)))	–105.0	–115.0	–125.0	–111.0	–121.0	–131.0
Orbital separation to meet AP **30** levels (degree)	9.7	3.8	2.7	5.6	3.1	1.9

FSS → BSS (Annex 4 to AP 30)

	Peak			**EOC**		
Type of FSS link	DTH	VSAT out bound	Point-to-point	DTH	VSAT out bound	Point-to-point
e.i.r.p. density of interfering network (dBW/MHz)	37.4	33.4	33.4	31.4	27.4	27.4
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–110.2	–124.2	–134.2	–116.2	–130.2	–140.2
Orbital separation to meet AP **30** levels (degree)	5.7	3.3	1.2	4.4	2.0	0.5

2 Study #2: Technical analyses of eastern limiting position for Region 2 BSS in 12.5-12.7 GHz

This frequency band has been used by FSS networks operating over the Region 1 areas.

In order to analyse the feasibility of such orbital arc extension to future Region 2 BSS networks, technical analyses were done to show necessary additional discrimination needed to be applied by BSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable.

Assumed parameters of representative Region 2 BSS networks and Region 1 FSS networks that were taken into account in the analyses are presented in Table A3-4 and Table A1-5.

TABLE A3-4

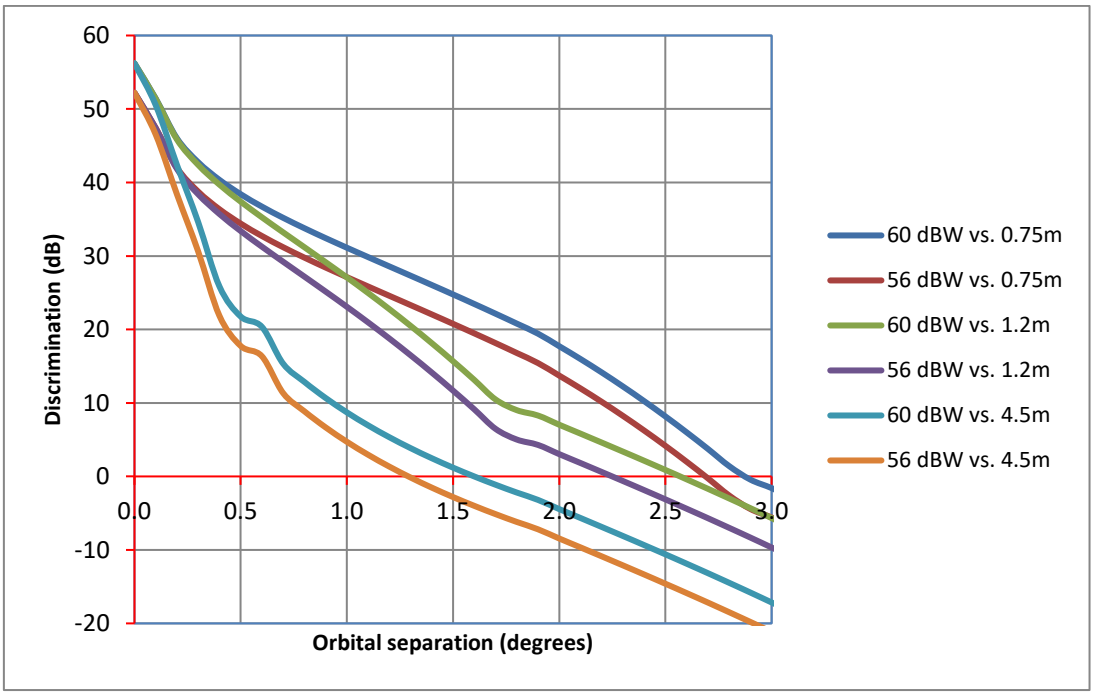
Representative Region 2 BSS network parameters

Type of service/carriers	DTH	DTH	DTH	DTH
Peak e.i.r.p. (dBW)	59.5	56.5	55.5	53.5
Channel Bandwidth (MHz)	24	24	24	24
Peak e.i.r.p. in 27 MHz	60	57	56	54
RX earth station antenna (m)	0.45	0.6	0.6	1.0
RX earth station gain (dBi)	33.3	35.8	35.8	40.3
RX earth station rad. pattern	BO.1213	BO.1213	BO.1213	BO.1213

The results of analysis for Region 2 BSS networks are shown in Fig. A3-7. As the needed discrimination is positive only for orbital separation of less than 3 degrees, only this part of results is shown in Fig. A3-7.

FIGURE A3-7

Needed discrimination for the Region 2 BSS around 54°W vs. Region 1 FSS case



From Fig. A3-7 it is visible that for all applied peak e.i.r.p. values for Region 2 BSS networks and earth station receiving antenna diameters in Table A3-4 for FSS networks in Region 1 no additional discrimination is needed for orbital separations larger than 2.9° in order to overcome coordination problems.

With 10 dB of discrimination these values would be in the range between 0.7° and 2.4°, depending on the combination of interfering e.i.r.p. and earth station receiving antenna diameter. With 20 dB of discrimination these values are between 0.4° and 1.8°.

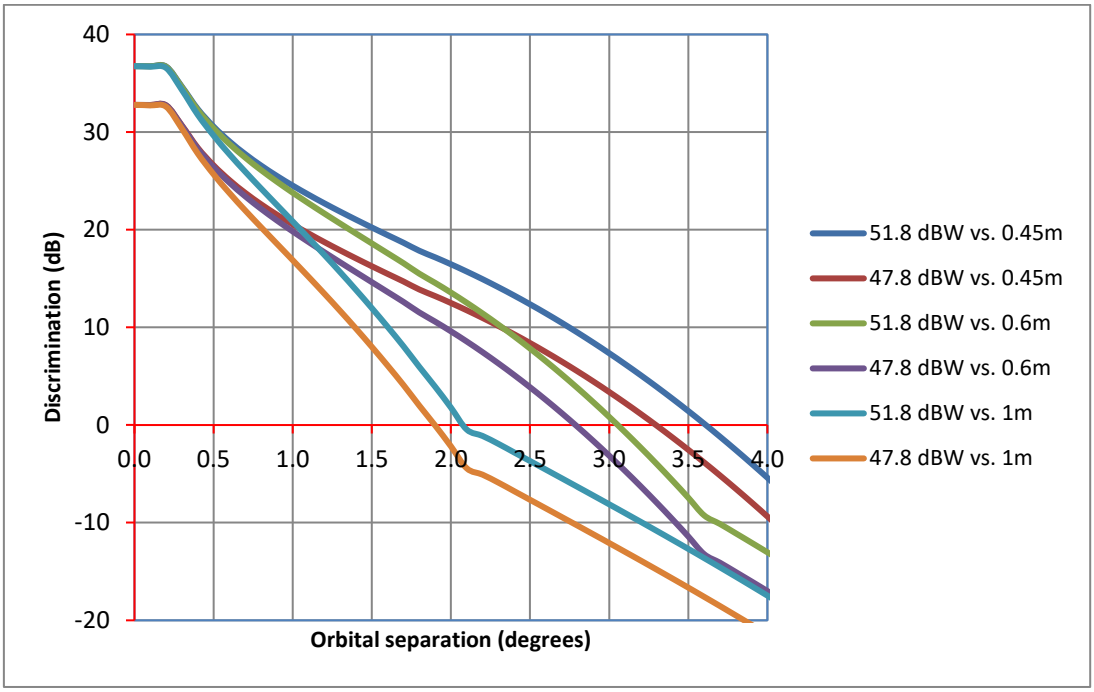
This shows that possible coordination scenarios between BSS networks in Region 2 and FSS networks in Region 1 are favourable if it exists sufficient geographical discrimination between FSS and BSS networks.

In the opposite case of sharing scenario (Region 1 FSS network vs. Region 2 BSS network) the situation is better due to the fact that unplanned FSS networks usually employ lower peak e.i.r.p. values, compared to planned BSS networks. On the other side, the necessity of protection of small Region 2 BSS receiving earth station antenna of 45 cm makes the sharing situation more difficult if such receiving earth station antennas would be used.

The results of analysis are shown in Fig. A3-8 for the orbital arc around 54°W.

FIGURE A3-8

Needed discrimination for the Region 1 FSS around 54ºW vs. Region 2 BSS case



In order to analyse the feasibility of such orbital arc extension, technical analyses were done to show necessary additional discrimination needed to be applied by FSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable.

As the needed discrimination is positive only for orbital separation smaller than 4 degrees, only this part of results is shown in Fig. A3-8.

From Fig. A3-8 it is visible that for all applied peak e.i.r.p. values for Region 1 FSS networks and Region 2 BSS representative earth station receiving antenna diameters no additional discrimination is needed for orbital separations bigger than 3.6° in order to overcome coordination problems.

With 10 dB of discrimination these values are in range between 1.4° and 2.7°, depending on the combination of interfering peak e.i.r.p. values of Region 1 FSS networks and the representative Region 2 BSS networks earth station receiving antenna diameter. With 20 dB of discrimination these values are between 0.8° and 1.6°.

In the case of sharing between interfering Region 1 FSS networks and victim Region 2 BSS networks the situation is generally more complicated due to necessity to protect 45 cm receiving earth station antennas of Region 2 BSS networks.

This shows that possible coordination scenarios between FSS networks in Region 1 and BSS networks operating in Region 2 are also favourable if it exists sufficient geographical discrimination between FSS and BSS networks.

Annex 4

Studies on Annex 7 limitation 'A2b' (i.e. no modifications in the Region 2 Plan further east than 44°W in the frequency band 12.2-12.5 GHz)

Summary of studies in this Annex are provided in § 9 above of the Report.

1 Study #1 Region 2 BSS and Region 1 BSS subject to Appendix 30 in 12.2-12.5 GHz

1.1 Assumed parameters for Region 1 BSS subject to Appendix 30 and Region 2 BSS

The following parameters are used:

TABLE A4-1

Assumed parameters for Region 1 BSS subject to Appendix 30

Type	DTH
Peak e.i.r.p. (dBW)	58/56
Transponder BW (MHz)	27
Carrier BW (MHz)	27
Peak e.i.r.p./carrier	58
EOC e.i.r.p./carrier	52
Receive earth station size (m)	0.6
Receive earth station gain (dBi)	35.7
Receive earth station antenna pattern	BO.1213

NOTE – The e.i.r.p. of any proposed new or modified assignment in the Regions 1 and 3 List of additional uses which lies within one of the portions of the orbital arc listed in Table 1 of Annex 7 shall not exceed 56 dBW, except at the positions listed in Table 2 of Annex 7 to RR Appendix **30**.

TABLE A4-2

Assumed parameters for Region 2 BSS

Type	DTH
Peak e.i.r.p. (dBW)	57
Transponder BW (MHz)	24
Carrier BW (MHz)	24
Peak e.i.r.p./carrier (dBW)	57
Peak e.i.r.p. density (dBW/MHz)	43.2
EOC e.i.r.p./carrier (dBW)	51
EOC e.i.r.p. density (dBW/MHz)	37.2
Receive earth station size (m)	0.45, 1

1.2 Results of analyses – Region 2 BSS into Region 1 BSS subject to Appendix 30 (section 3 of Annex 1 to RR Appendix 30)

Figure A4-1 provides an assessment of the orbital separation where the representative BSS networks in Table A4-2 would meet the limits of section 3 of Annex 1 to RR Appendix **30** coordination trigger levels to protect Region 1 BSS subject to Appendix **30**. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 1 BSS network are assumed.

FIGURE A4-1

Comparison of representative BSS pfd levels with those in section 3 of Annex 1 at 12 GHz

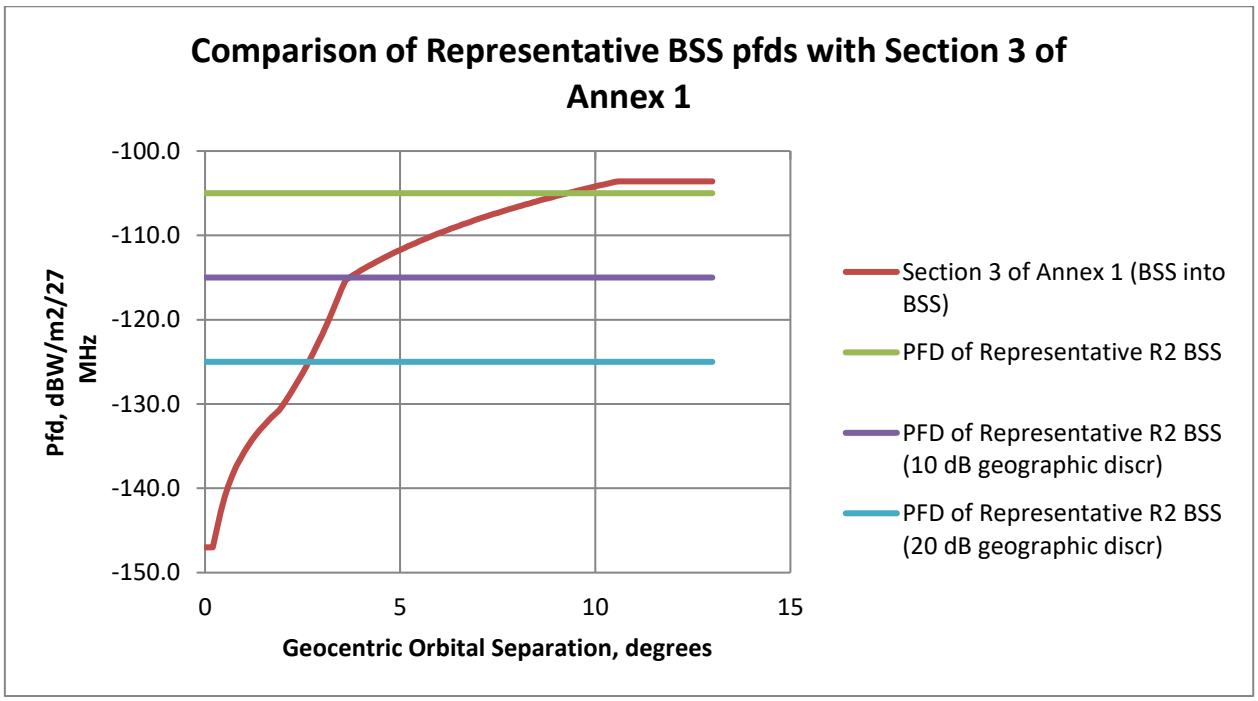


Figure A4-2 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A4-2 above, assuming a minimum of 10 dB of geographic discrimination from the Region 1 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle

specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

It is noted that examples demonstrate that a minimum assumption of 20 dB of geographic discrimination is feasible between Regions 1 and 2.

Considering the same assumptions, Fig. A4-3 shows the resulting *C*/*Is* levels into the representative BSS parameters provided in Table A4-2 above assuming the maximum level from the Region 1 BSS according to section 3 of Annex 1 of Appendix **30**.

FIGURE A4-2

***C*/*I* levels into Region 1 BSS from representative Region 2 BSS with 10 dB geographic discrimination at 12 GHz**

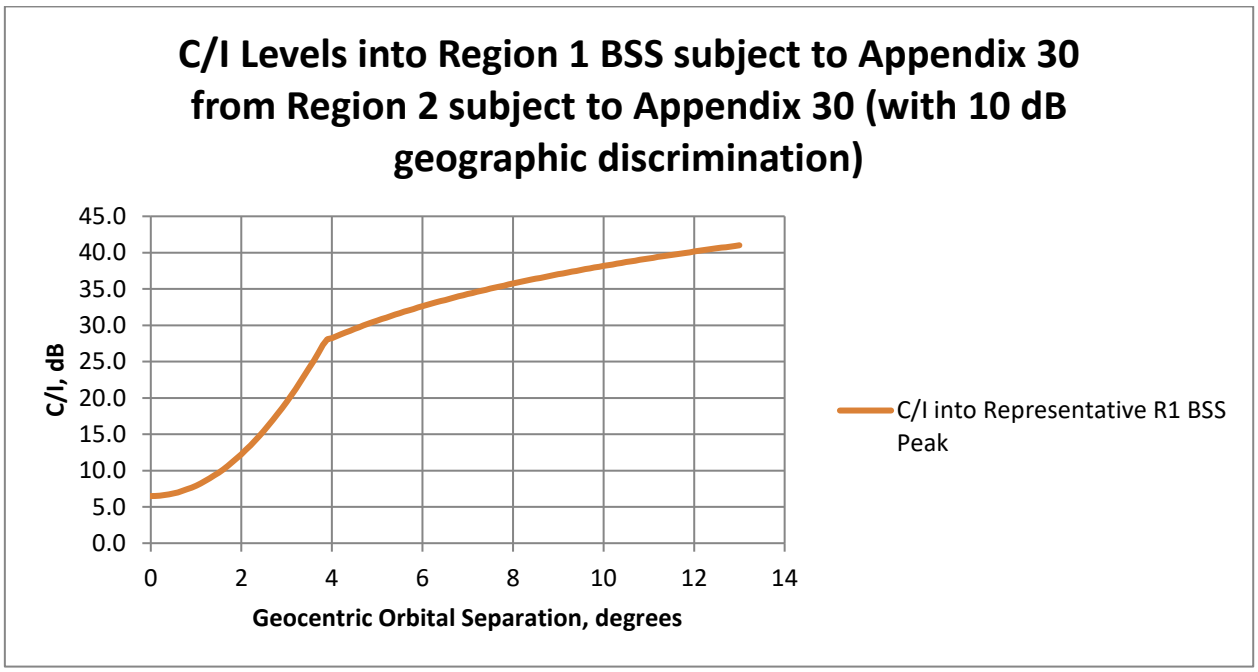
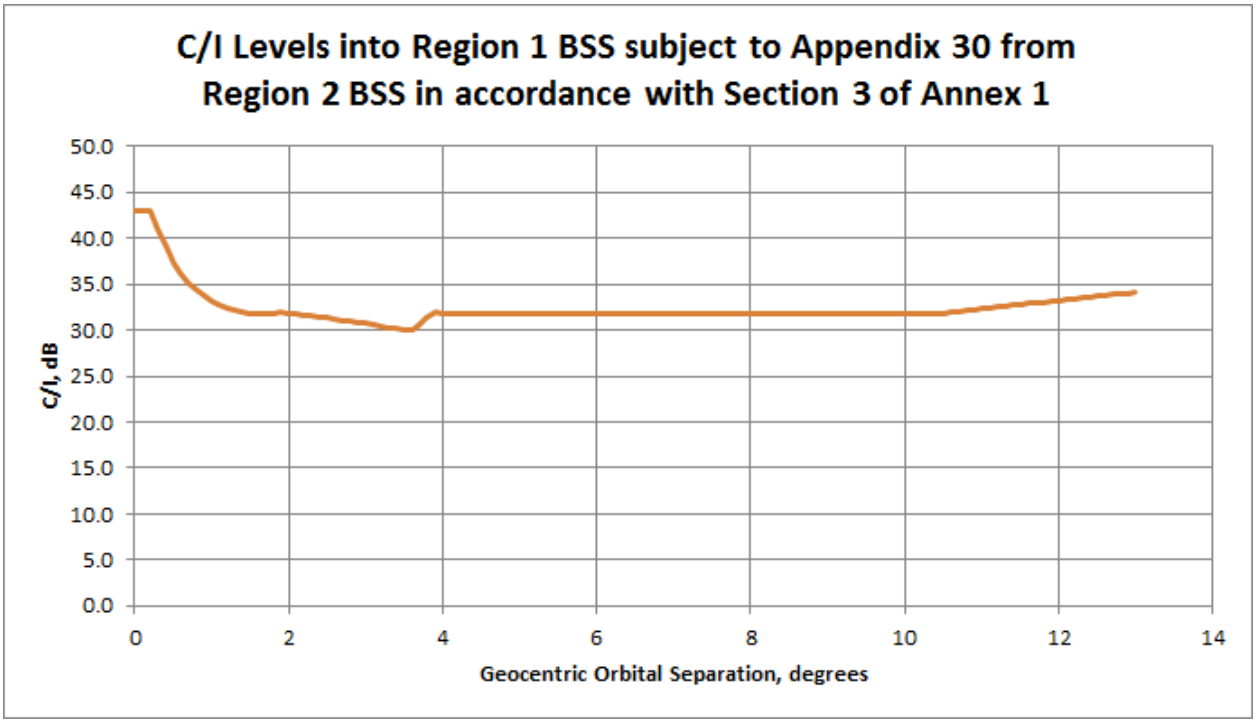


FIGURE A4-3

***C/I* levels into Region 1 BSS subject to Appendix 30 from Region 2 BSS in accordance with section 3 of Annex 1 of Appendix 30**



1.3 Results of analyses – Region 1 BSS into Region 2 BSS subject to Appendix 30 (section 3 of Annex 1 to RR Appendix 30)

Figure A4-4 provides an assessment of the orbital separation where the representative BSS networks in Table A4-1 would meet the limits of section 3 of Annex 1 to RR Appendix **30** coordination trigger levels to protect Region 2 BSS subject to Appendix **30**. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 2 BSS network are assumed.

FIGURE A4-4

Comparison of representative BSS pfd levels with those in section 3 of Annex 1 at 12 GHz

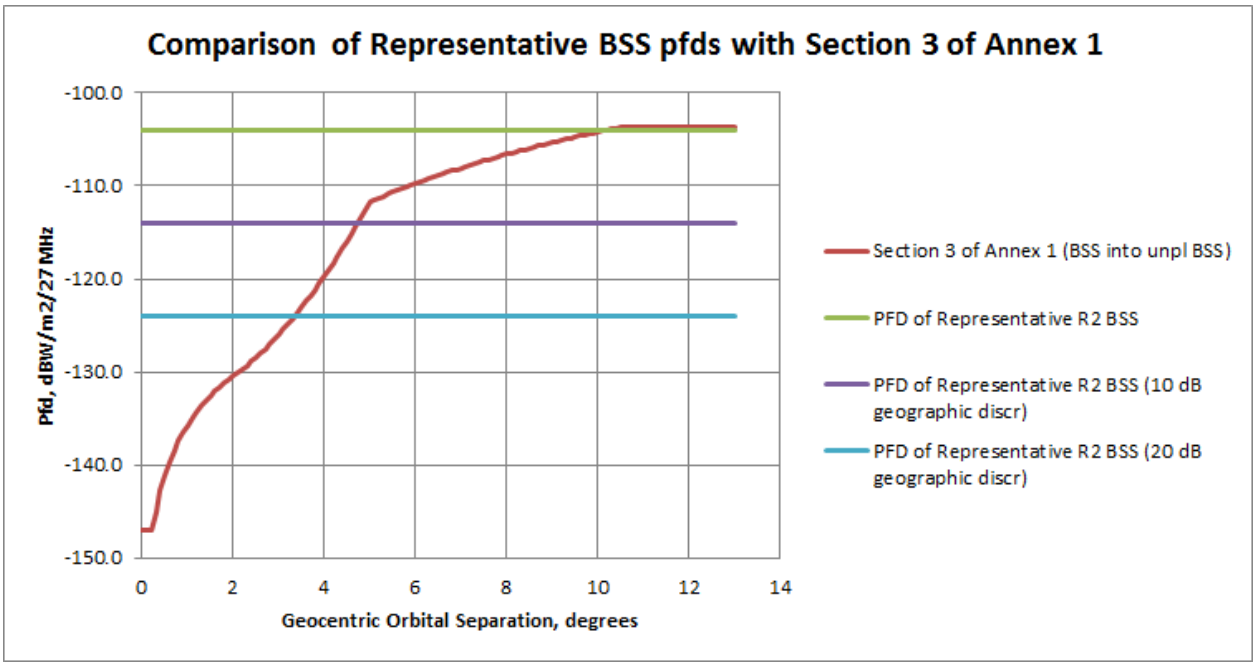


Figure A4-5 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A4-1 above, assuming a minimum of 10 dB of geographic discrimination from the Region 2 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/27 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/27 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

It is noted that examples demonstrate that a minimum assumption of 20 dB of geographic discrimination is feasible between Regions 1 and 2.

Considering the same assumptions, Fig. A4-6 shows the resulting *C*/*Is* levels into the representative BSS parameters provided in Table A4-1 above assuming the maximum level from the Region 2 BSS according to section 3 of Annex 1 of Appendix **30**.

FIGURE A4-5

***C/I* levels into Region 2 BSS from representative Region 1 BSS with 10 dB geographic discrimination at 12 GHz**

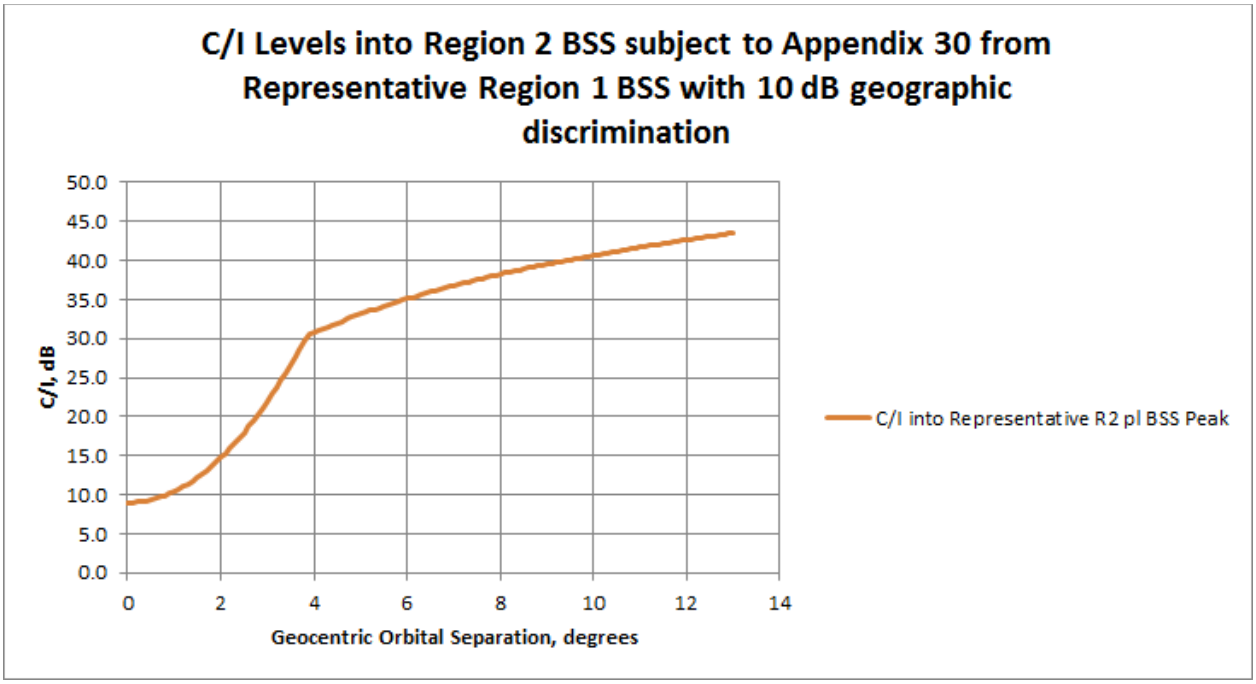


FIGURE A4-6

***C/I* levels into Region 2 BSS subject to Appendix 30 from Region 1 BSS in accordance with section 3 of Annex 1 of Appendix 30**

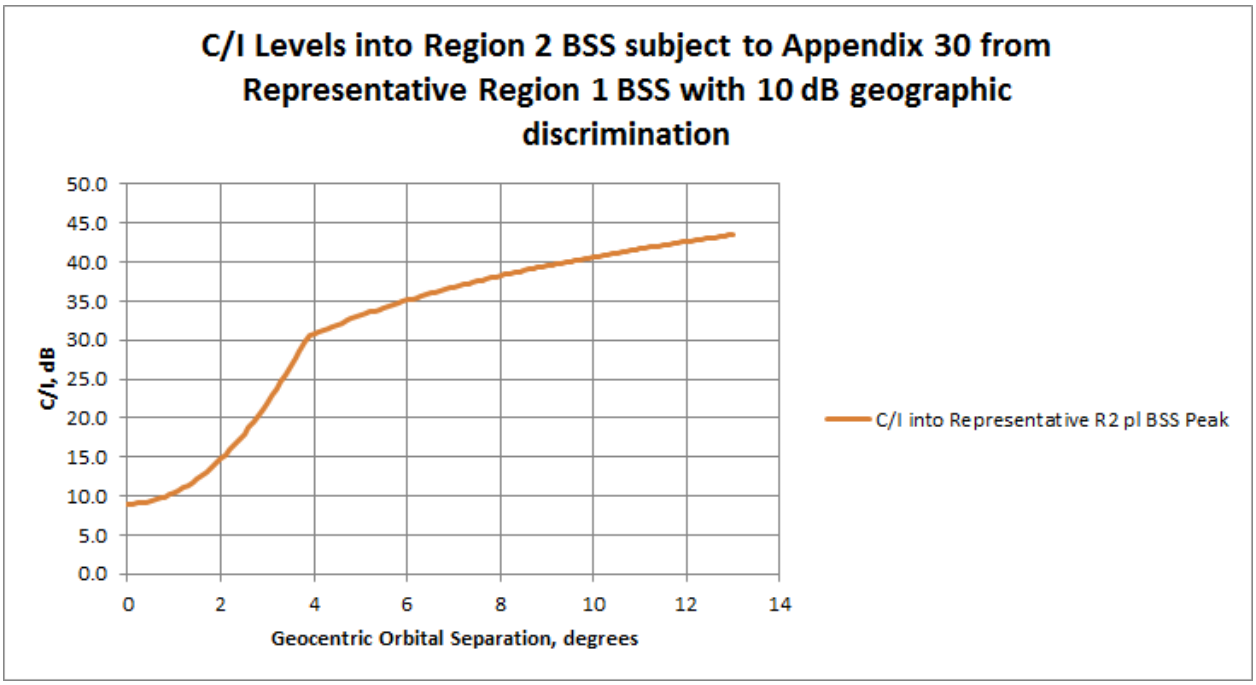


TABLE A4-3

Results of analysis for orbital separations to avoid triggering coordination between Region 1 BSS and Region 2 BSS in 12.2-12.5 GHz

BSS Region 2→ BSS Region 1 (section 3 of Annex 1 to AP 30)

	Peak			EOC		
e.i.r.p. density of interfering network (dBW/MHz)	43.2	43.2	43.2	37.2	37.2	37.2
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–105.0	–115.0	–125.0	–111.0	–121.0	–131.0
Orbital separation to meet AP **30** levels (degree)	9.7	3.9	2.7	5.6	3.2	2.0

BSS Region 1→ BSS Region 2 (section 3 of Annex 1 to AP 30)

	Peak			EOC		
e.i.r.p. density of interfering network (dBW/MHz)	43.7	43.7	43.7	37.7	37.7	37.7
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	–10.0	–20.0	0.0	–10.0	–20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–104	–114	–124	–110	–120	–130
Orbital separation to meet AP **30** levels (degree)	10.2	4.7	3.3	5.8	3.9	2.1

2 Study #2: Technical analyses of eastern limiting position for Region 2 BSS in 12.2-12.5 GHz

In order to analyse the feasibility of such orbital arc extension, technical analyses were done to show necessary discrimination needed by Region 2 BSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable.

Assumed parameters of representative Region 2 BSS networks and Region 1 BSS networks that were taken into account in the analyses are presented in Table A4-1 and Table A4-2.

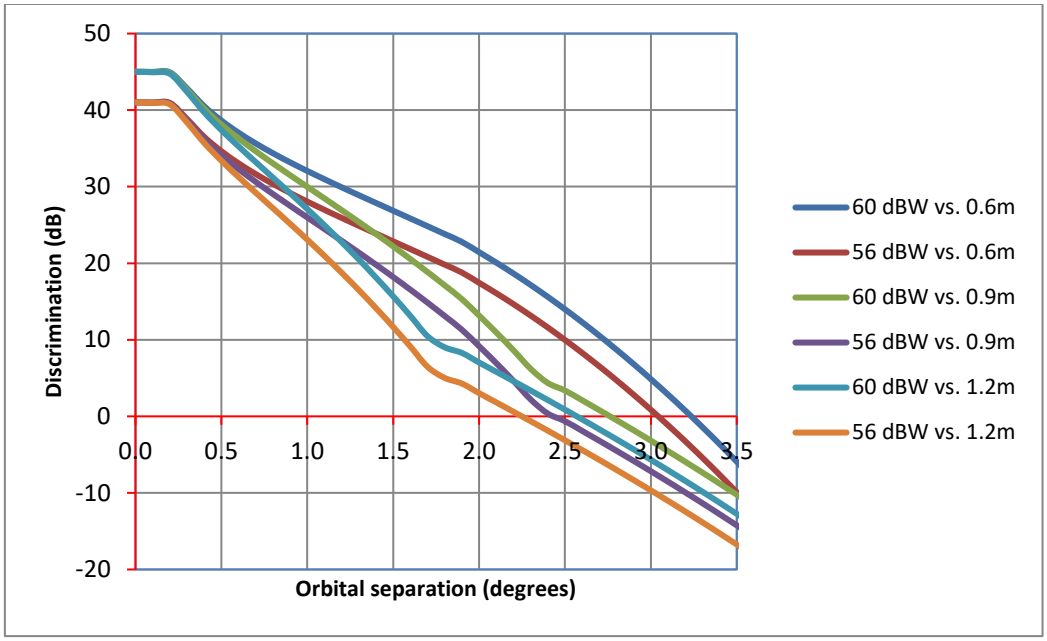
The results of analysis are shown in Fig. A4-7. As the needed discrimination is positive only for orbital separation smaller than 3.5 degrees, only this part of results is shown in Fig. A4-7.

From Fig. A4-7 it is visible that for all applied peak e.i.r.p. values for Region 2 BSS networks and the representative Region 1 BSS networks earth station receiving antenna diameters no additional discrimination is needed for orbital separations bigger than 3.2° in order to overcome coordination problems.

With 10 dB of discrimination these values would be in the range between 1.6° and 2.7°, depending on the combination of Region 2 BSS network peak e.i.r.p. and the Region 1 BSS network earth station receiving antenna diameter. With 20 dB of discrimination these values are between 1.2° to 2.2°.

FIGURE A4-7

Needed discrimination for the Region 2 BSS around 44ºW versus Region 1 BSS case



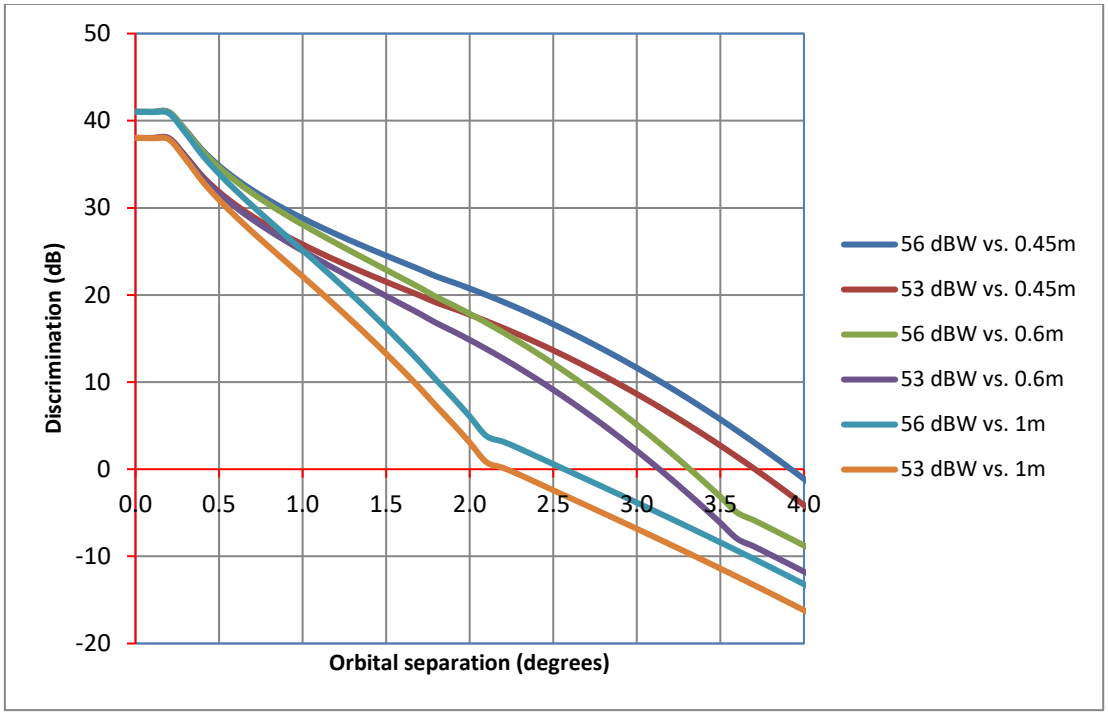
This sharing scenario represents a special case as it involves two planned BSS networks operating in different world Regions, and they are part of different BSS Plan and/or BSS List.

For the interfering Region 2 BSS network the worst case represents the usage of very high peak e.i.r.p. values with respect to victim Region 1 BSS networks with earth station receiving antennas of very small diameter. In such a case, bigger values of discrimination would be necessary in order to overcome coordination problems. The usage of lower peak e.i.r.p. values simplifies the situation even with smaller receiving earth station antenna diameters.

In the opposite case of sharing scenario (Region 1 BSS network vs. Region 2 BSS network) the situation is similar to the previous case. The results of analysis are shown in Fig. A4-8. As the needed discrimination is positive only for orbital separation smaller than 4 degrees, only this part of results is shown in Fig. A4-8.

FIGURE A4-8

Needed discrimination for the Region 1 BSS around 44ºW versus Region 2 BSS case



From Fig. A4-8 it is visible that for all applied peak e.i.r.p. values for Region 1 BSS networks and Region 2 BSS representative earth station receiving antenna diameters no additional discrimination is needed for orbital separations bigger than 3.9° in order to overcome coordination problems.

With 10 dB of discrimination these values are in the range between 1.7° and 3.2°, depending on the combination of interfering peak e.i.r.p. values of Region 1 BSS networks and the representative Region 2 BSS networks earth station receiving antenna diameter. With 20 dB of discrimination these values are between 1.2° and 2.1°.

Due to the fact that planned BSS networks in Region 1 usually employ lower peak e.i.r.p. values compared to planned BSS networks in Region 2, the sharing situation is more favourable for small orbital separations.

On the other side, the necessity to protect very small Region 2 BSS receiving earth station antennas of 45 cm makes the sharing situation more difficult for larger orbital separations (>2.5°).

However, by applying 20 dB of discrimination, which could be feasible due to presence of the Atlantic Ocean, the coordination problem would be minimal for orbital separation larger than 2°, except in the cases of maximum peak e.i.r.p. applied for Region 1 BSS networks against BSS networks in Region 2 with very small earth station antenna diameters.

This shows that possible coordination scenarios between BSS networks in Region 1 and BSS networks in Region 2 are favourable but a bit worse than in other cases due to necessity to protect Region 2 BSS receiving earth station antennas with very small diameters (45 cm).

Annex 5

Studies on Annex 7 limitation 'A2c' (i.e. No modifications in the Region 2 Plan further west than 175.2°W in the frequency band 12.2-12.7 GHz)

1 Study #1: Sharing study between Region 2 BSS and Region 3 FSS networks in 12.2-12.7 GHz

A determination is made of the orbital separation for various e.i.r.p. levels of representative BSS and FSS networks to meet the Annex 1 and/or Annex 4 pfd masks. In addition, the *C*/*I* level is calculated for various orbital separations within the Annex 7 arc using representative BSS and FSS network parameters.

1.1 Assumed parameters for Region 2 BSS and Region 3 FSS

The same parameters provided in Table A3-1 are used for Region 2 BSS. The parameters used for Region 3 FSS are provided below.

TABLE A5-1

Assumed Region 3 FSS parameters

Type	DTH	VSAT outbound	Point-to-point
Peak e.i.r.p. (dBW)	53	53	53
Transponder BW (MHz)	36	36	36
Carrier BW (MHz)	36	8	1.2
Peak e.i.r.p./carrier	53	42.5	34.2
EOC e.i.r.p./carrier	47	36.5	28.2
Receive earth station size (m)	0.75	1.2	4.5
Receive earth station gain (dBi)	37.6	41.7	53.2
Receive earth station antenna pattern	BO.1213	BO.1213	BO.1213

NOTE – Recommendation ITU-R BO.1213 intends to establish reference earth station co-polar and cross-polar antenna patterns for the broadcasting-satellite service (BSS) in the 11.7-12.75 GHz frequency band.

1.2 Results of analyses – Region 2 BSS into Region 3 FSS (section 6 of Annex 1 to RR Appendix 30)

Figure A5-1 provides an assessment of the orbital separation where the representative BSS network in Table A5-1 would meet the section 6 of Annex 1 to RR Appendix **30** coordination trigger levels. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 2 BSS network are assumed.

FIGURE A5-1

Comparison of representative BSS pfd levels with those in section 6 of Annex 1 at 12.2 GHz

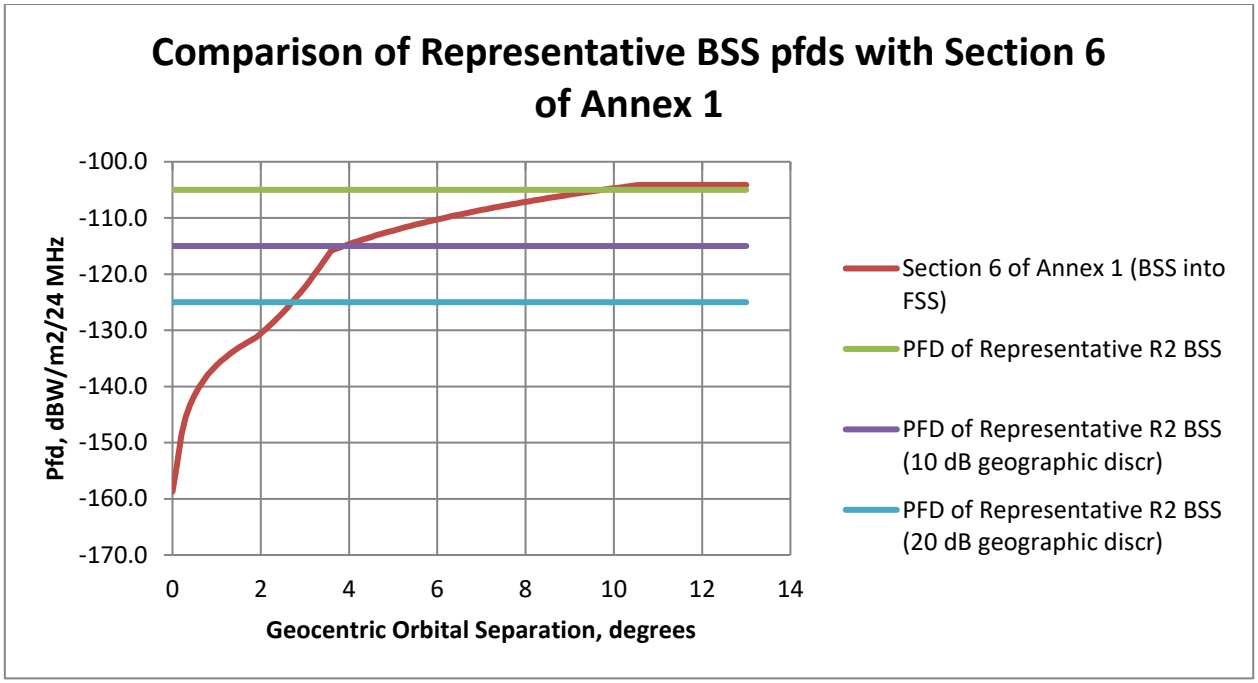


Figure A5-2 shows the resulting *C*/*I*s into the representative FSS parameters provided in Table A5-1 assuming a minimum of 10 dB of geographic discrimination from the Region 2 BSS beam. The *C/I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak FSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A5-3 shows the resulting *C*/*Is* levels into the representative FSS parameters provided in Table A5-2 above assuming the maximum level from the Region 2 BSS according to section 6 of Annex 1 of Appendix **30**.

FIGURE A5-2

***C/I* levels into Region 3 FSS from representative Region 2 BSS with 10 dB geographic discrimination at 12.2 GHz**

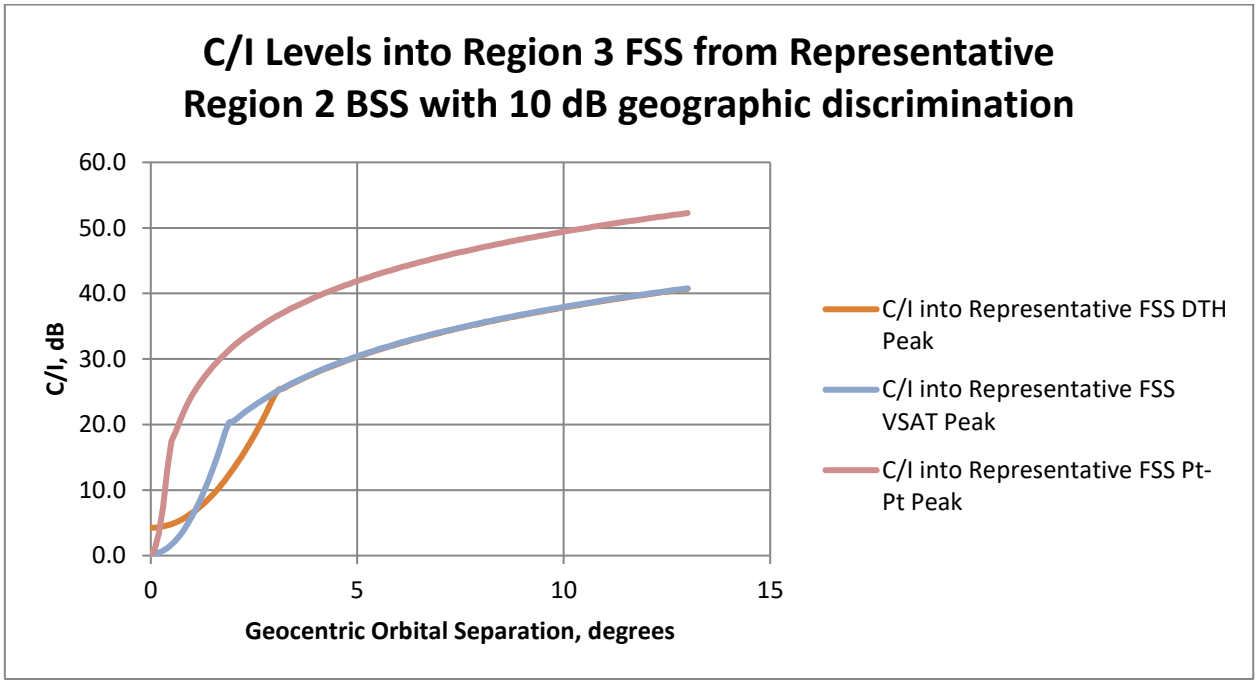
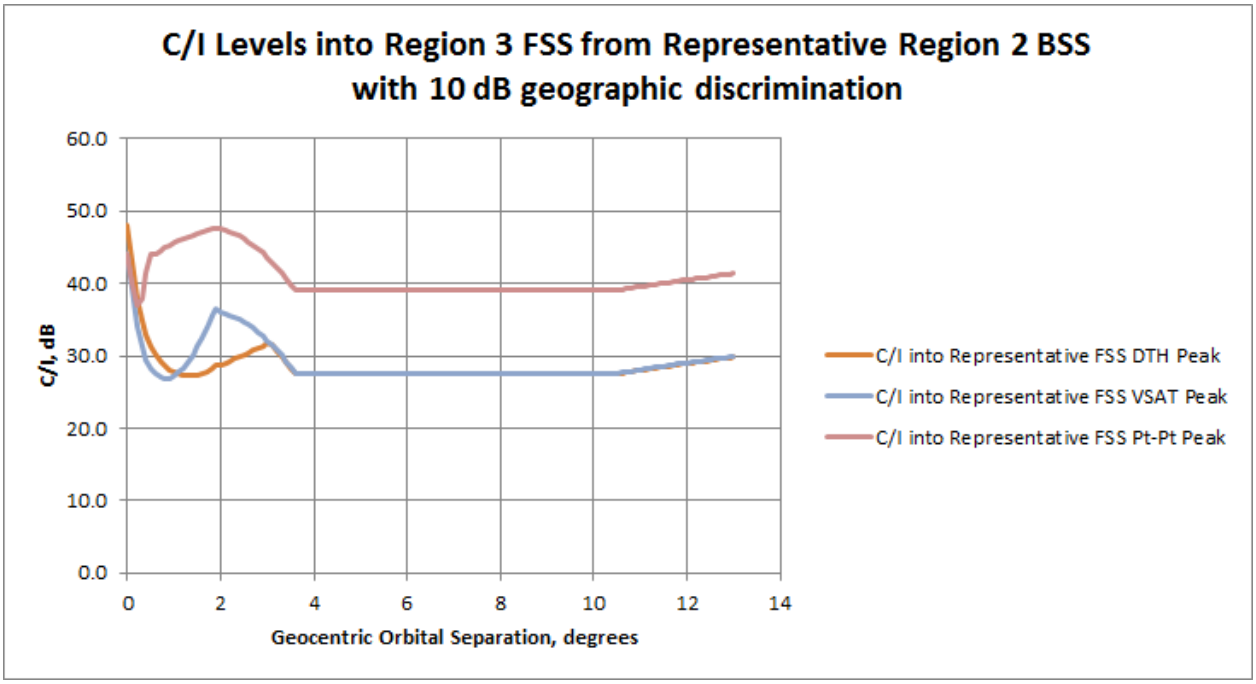


FIGURE A5-3

***C/I* levels into Region 3 FSS from Region 2 BSS in accordance with section 6 of Annex 1 of Appendix 30**



1.3 Results of analyses – Region 3 FSS into Region 2 BSS (Annex 4 to RR Appendix 30)

Figure A5-4 provides an assessment of the orbital separation assuming a geographic discrimination of 10 dB where the representative FSS networks in Table A5-1 would meet the Annex 4 to RR Appendix **30** coordination trigger levels. Varying levels of geographic discrimination of the Region 3 FSS networks could be assumed.

FIGURE A5-4

Comparison of representative FSS pfd levels with those in Annex 4 at 12.2 GHz

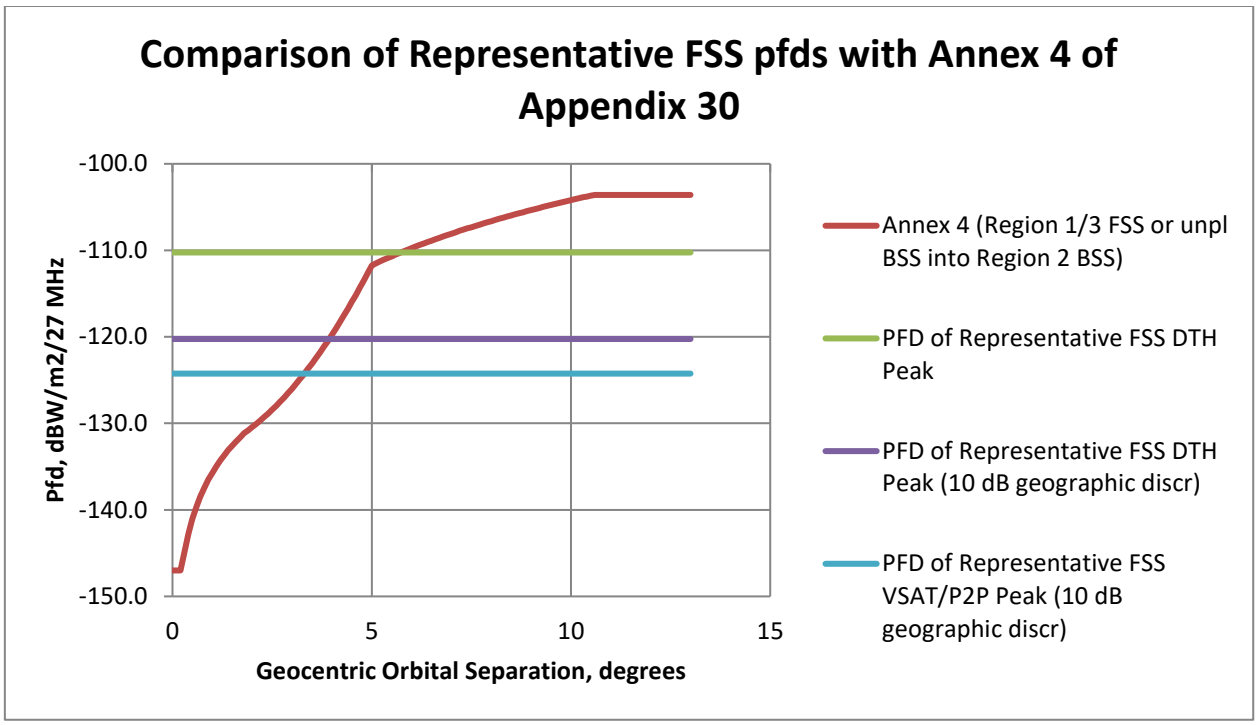


Figure A5-5 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A5-1 assuming a minimum of 10 dB of geographic discrimination from the Region 3 FSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

FIGURE A5-5

***C/I* levels into Region 2 BSS from representative Region 3 FSS at 12.2 GHz**

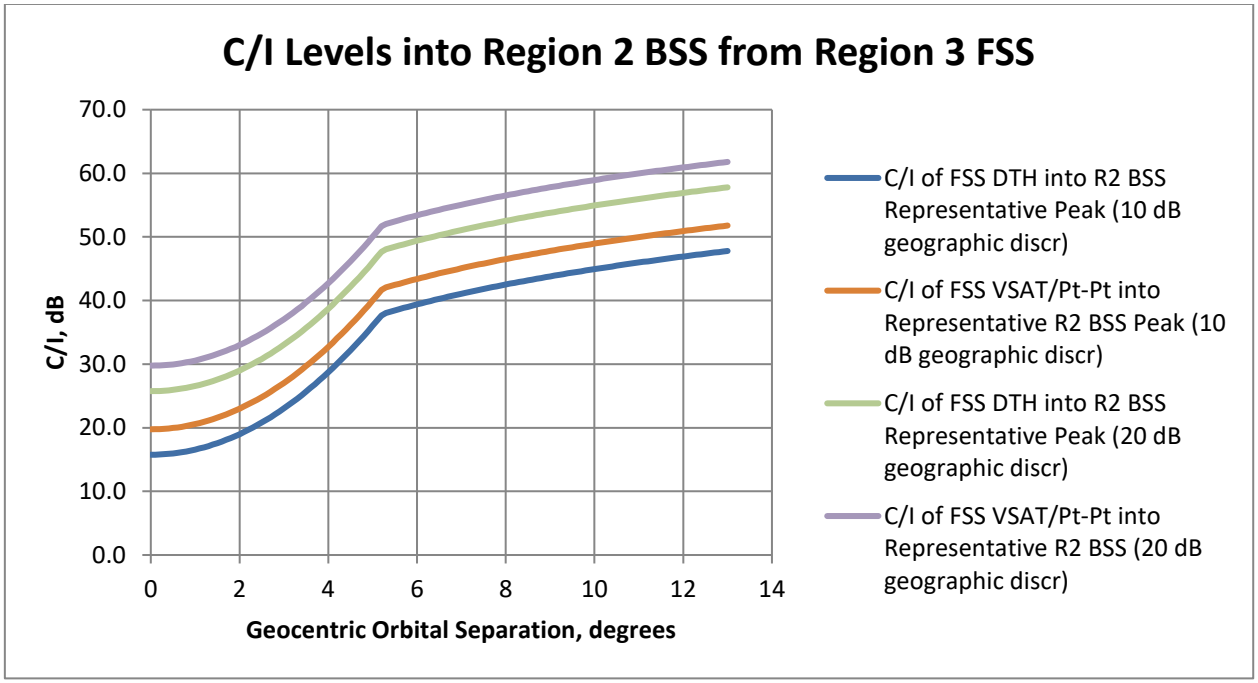


FIGURE A5-6

***C/I* levels into Region 2 BSS from Region 3 FSS in accordance with Annex 4 of Appendix 30**

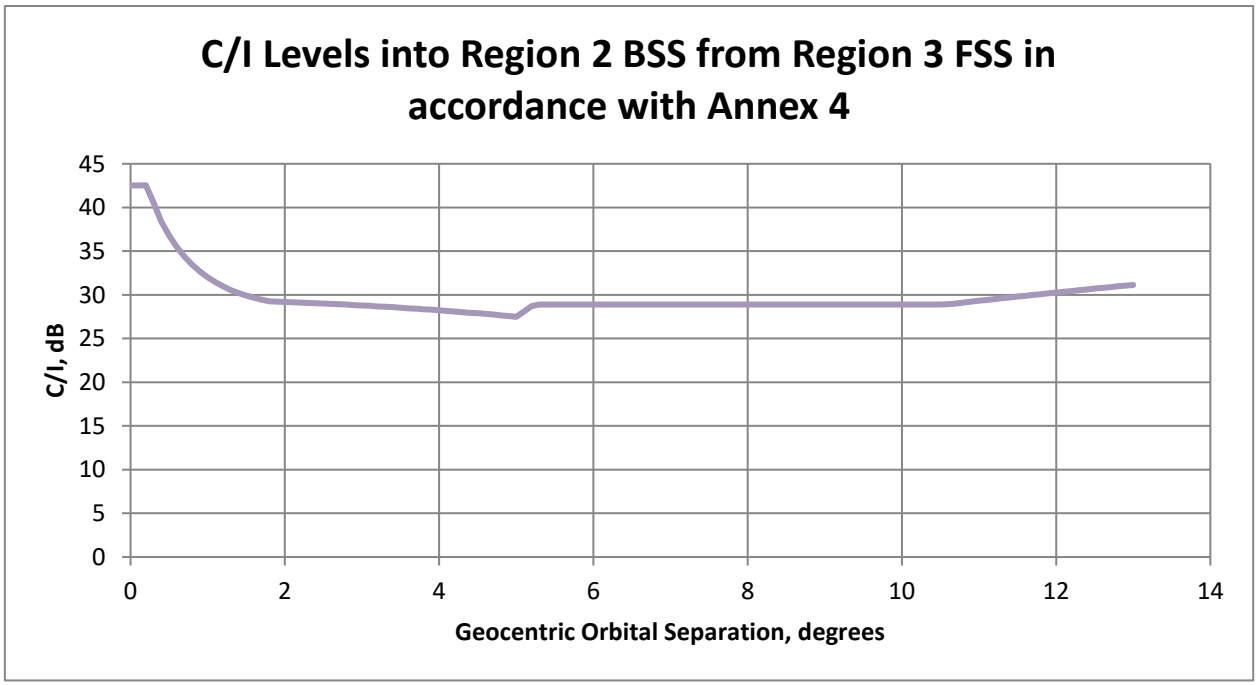


TABLE A5-2

Results of analysis for orbital separations to avoid triggering coordination between Region 2 BSS and Region 3 FSS in 12.2-12.7 GHz

BSS → FSS (section 6 of Annex 1 to AP 30)

	Peak			EOC		
e.i.r.p. density of interfering network (dBW/MHz)	43.2	43.2	43.2	37.2	37.2	37.2
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	−10.0	−20.0	0.0	−10.0	−20.0
Associated pfd (dB(W/(m^2 · 24 MHz)))	−104.5	−114.5	−124.5	−110.5	−120.5	−130.5
Orbital separation to meet AP **30** levels (degree)	10.2	4.0	2.7	5.8	3.1	2.0

FSS → BSS (Annex 4 to AP 30)

	Peak			EOC		
Type of FSS link	DTH	VSAT out bound	Point-to-point	DTH	VSAT out bound	Point-to-point
e.i.r.p. density of interfering network (dBW/MHz)	37.4	33.4	33.4	31.4	27.4	27.4
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	−10.0	-20.0	0.0	−10.0	−20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	–110.2	–124.2	−134.2	–116.2	–130.2	–140.2
Orbital separation to meet AP **30** levels (degree)	5.7	3.3	1.2	4.4	2.0	0.5

2 Study #2: Region 2 BSS vis a vis Region 1 FSS in 12.5-12.7 GHz (Pacific)

2.1 Assumed parameters for Region 2 BSS and Region 1 FSS

The same parameters provided in section A3-1.1 are used in this section.

2.2 Results of analyses – Region 2 BSS into Region 1 FSS (section 6 of Annex 1 to RR Appendix 30)

Figure A5-7 provides an assessment of the orbital separation where the representative BSS network in Table A3-1 would meet the section 6 of Annex 1 to RR Appendix **30** coordination trigger levels. Given the geographic separation between Regions 1 and 2, and the antenna pattern roll-off values of 0 dB, 10 dB and 20 dB, varying levels of geographic discrimination of the Region 2 BSS network are assumed.

FIGURE A5-7

Comparison of representative BSS pfd levels with those in section 6 of Annex 1 at 12.5 GHz

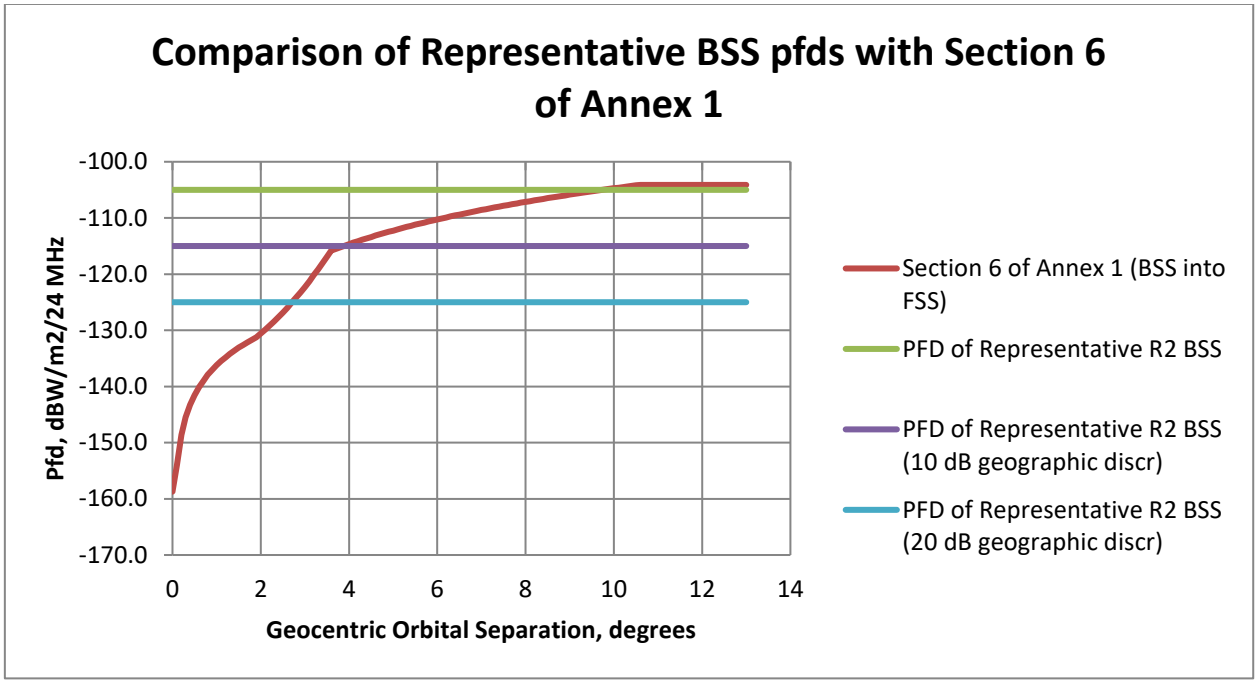


Figure A5-8 shows the resulting *C*/*I*s into the representative FSS parameters provided in Table A3-2 assuming a minimum of 10 dB of geographic discrimination from the Region 2 BSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak FSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A5-9 shows the resulting *C*/*Is* levels into the representative FSS parameters provided in Table A3-2 above assuming the maximum level from the Region 2 BSS according to section 6 of Annex 1 of Appendix **30**.

FIGURE A5-8

***C/I* levels into Region 1 FSS from representative Region 2 BSS with 10 dB geographic discrimination at 12.5 GHz**

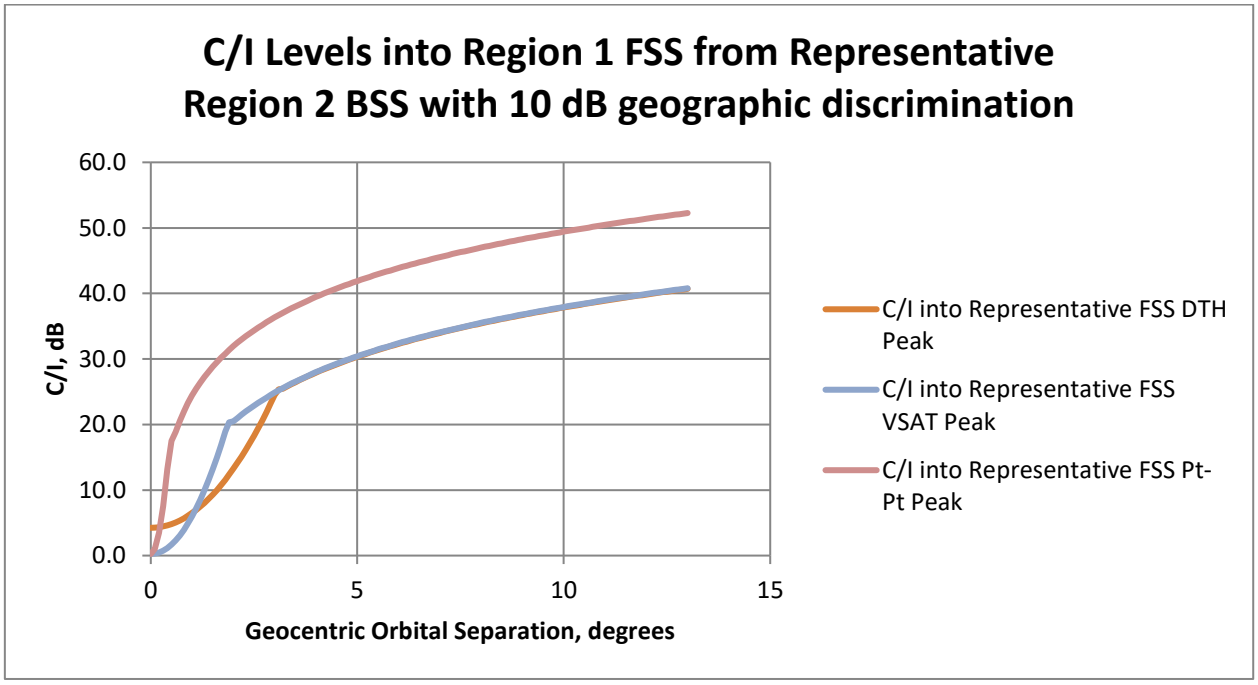
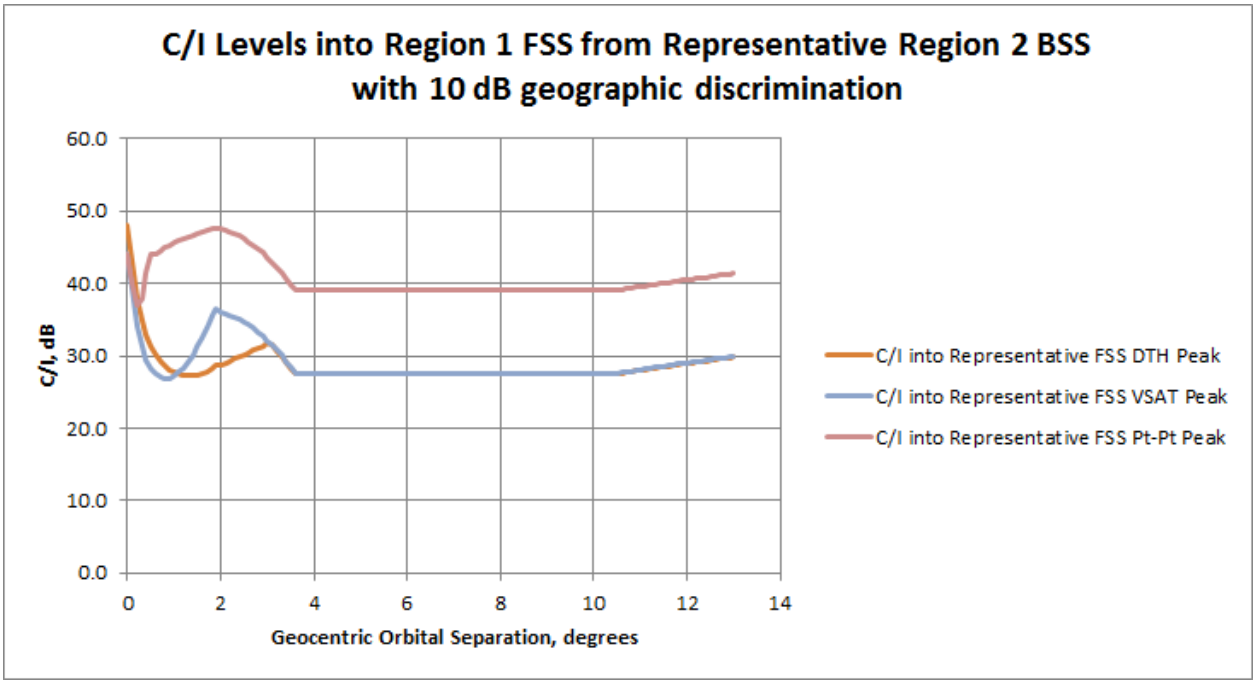


FIGURE A5-9

***C/I* levels into Region 1 FSS from Region 2 BSS in accordance with section 6 of Annex 1 of Appendix 30**



2.3 Results of analyses – Region 1 FSS into Region 2 BSS (Annex 4 to RR Appendix 30)

Figure A5-10 provides an assessment of the orbital separation assuming a geographic discrimination of 10 dB where the representative FSS networks in Table A3-2 would meet the Annex 4 to RR Appendix **30** coordination trigger levels. Varying levels of geographic discrimination of the Region 1 FSS networks could be assumed.

FIGURE A5-10

Comparison of representative FSS pfd levels with those in Annex 4 at 12.5 GHz

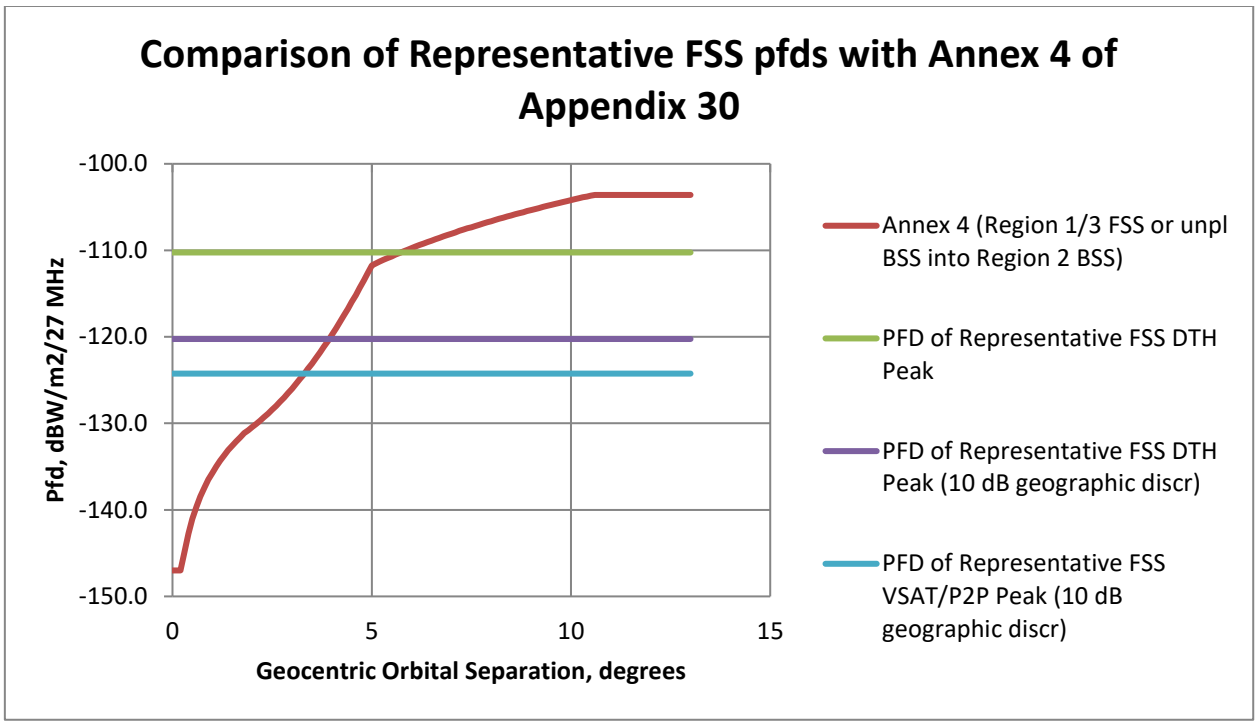


Figure A5-11 shows the resulting *C*/*I*s into the representative BSS parameters provided in Table A3-1 assuming a minimum of 10 dB of geographic discrimination from the Region 1 FSS beam. The *C*/*I* is calculated as follows: the wanted e.i.r.p. (dBW/24 MHz) + earth station antenna on-axis gain (dBi) – (interfering e.i.r.p. (dBW/24 MHz) + satellite antenna off-axis gain at the off-axis angle specified (dBi)) + geographic discrimination (dB). The Figure is based on peak BSS e.i.r.p. levels; there are numerous combinations of e.i.r.p. levels that can be easily determined by scaling these results.

Considering the same assumptions, Fig. A5-12 shows the resulting *C*/*Is* levels into the representative BSS parameters provided in Table A3-1 above assuming the maximum level from the Region 1 FSS according to Annex 4 of Appendix **30**.

FIGURE A5-11

***C/I* levels into Region 2 BSS from representative Region 1 FSS at 12.5 GHz**

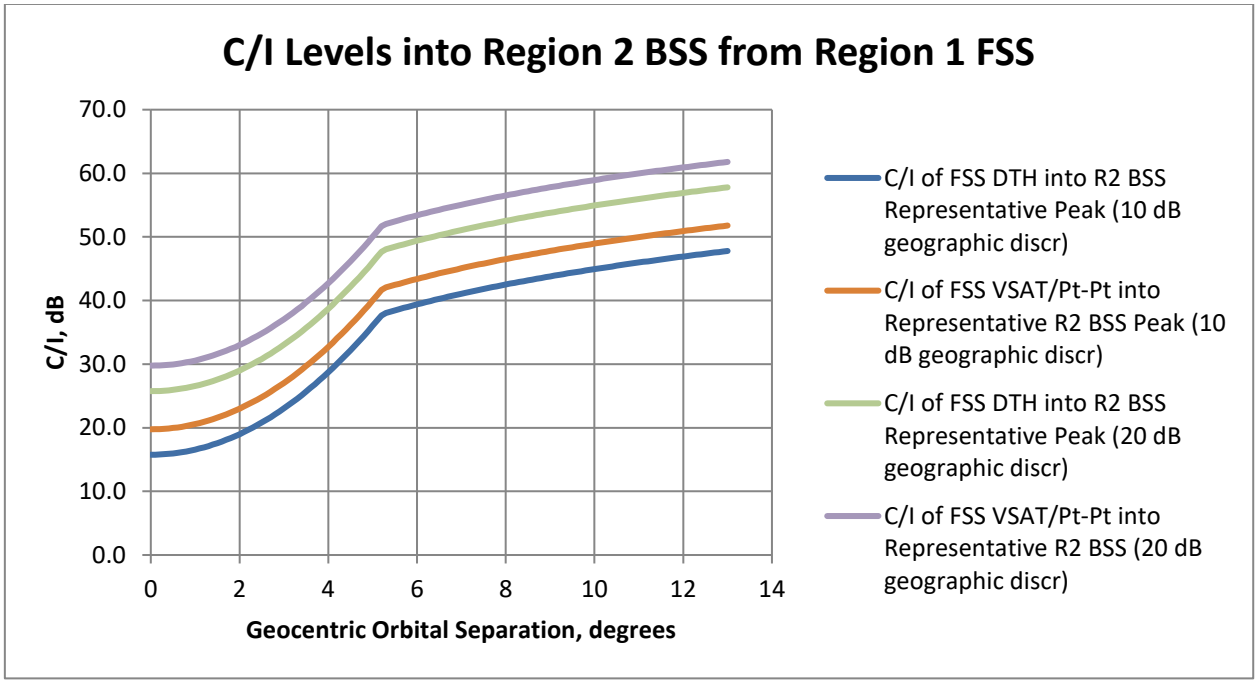


FIGURE A5-12

***C/I* levels into Region 2 BSS from Region 1 FSS in accordance with Annex 4 of Appendix 30**

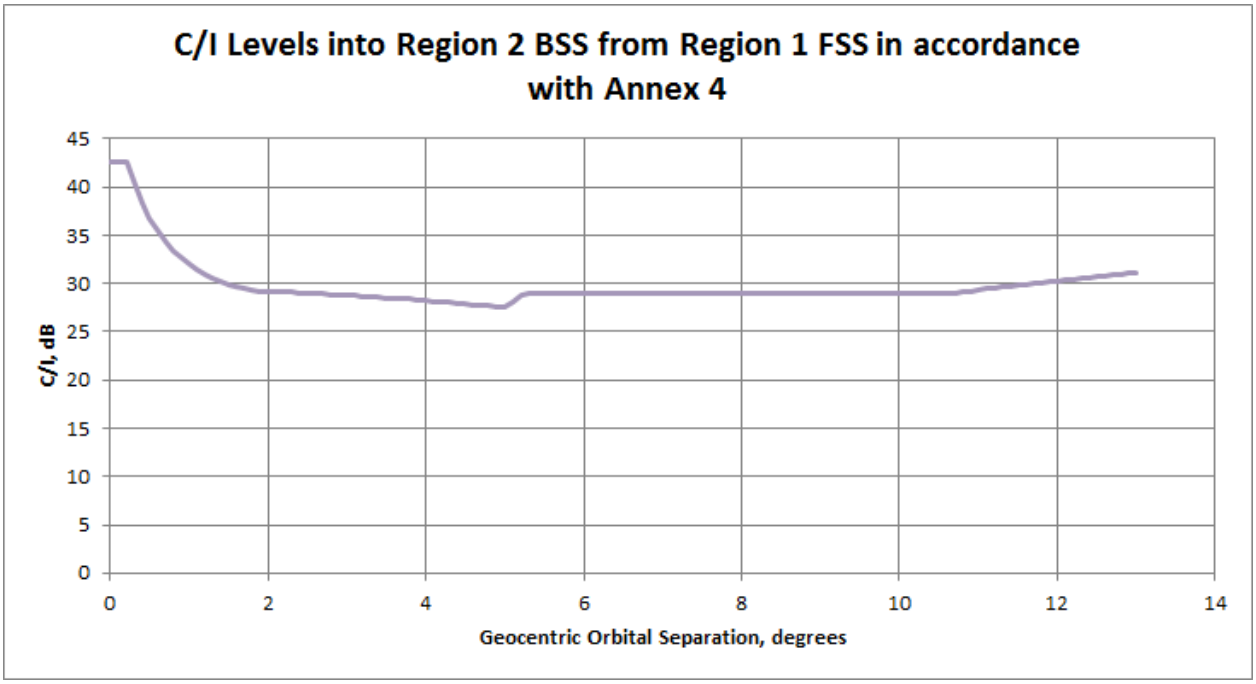


TABLE A5-3

Results of analysis for orbital separations to avoid triggering coordination between Region 2 BSS and Region 1 FSS in 12.5-12.7 GHz

BSS → FSS (section 6 of Annex 1 to AP 30)

	Peak			**EOC**		
e.i.r.p. density of interfering network (dBW/MHz)	43.2	43.2	43.2	37.2	37.2	37.2
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	10.0	20.0	0.0	10.0	20.0
Associated pfd (dB(W/(m^2 · 24 MHz)))	−105.0	−115.0	−125.0	−111.0	−121.0	−131.0
Orbital separation to meet AP **30** levels (degree)	9.7	3.8	2.7	5.6	3.1	1.9

FSS → BSS (Annex 4 to AP 30)

	Peak			**EOC**		
Type of FSS link	DTH	VSAT out bound	Point-to-point	DTH	VSAT out bound	Point-to-point
e.i.r.p. density of interfering network (dBW/MHz)	37.4	33.4	33.4	31.4	27.4	27.4
Relative Antenna gain contour at Region 1/ Region 2 border (dB)	0.0	10.0	20.0	0.0	10.0	20.0
Associated pfd (dB(W/(m^2 · 27 MHz)))	−110.2	−124.2	−134.2	−116.2	−130.2	−140.2
Orbital separation to meet AP **30** levels (degree)	5.7	3.3	1.2	4.4	2.0	0.5

3 Study #3: Technical analyses of western limiting orbital position for Region 2 BSS

In order to analyse the feasibility of such orbital arc extension, technical analyses were done to show necessary discrimination needed by Region 2 BSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable.

Assumed parameters of representative Region 2 BSS networks and Region 3 FSS networks that were taken into account in the analyses are presented in Table A3-1 and Table A5-1 respectively.

The results of analysis are shown in Fig. A5-13. As the needed discrimination is positive only for orbital separation smaller than 3 degrees, only this part of results is shown in Fig. A5-13.

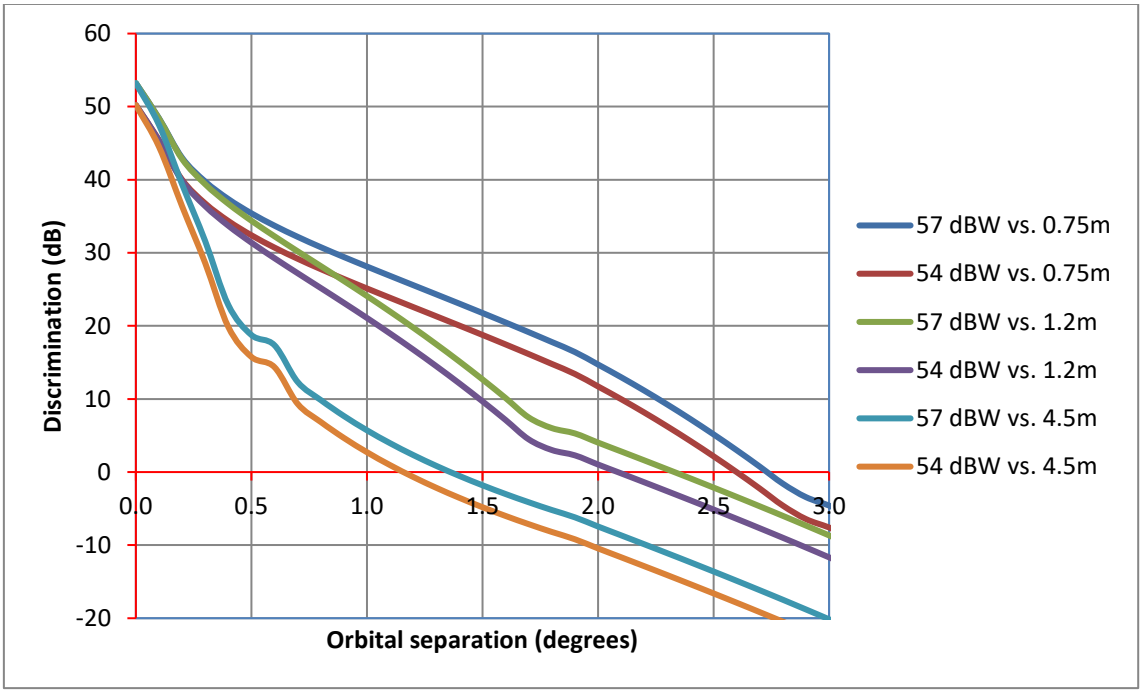
Figure A5-13 shows that for all applied peak e.i.r.p. values to Region 2 BSS networks and the Region 3 representative earth station receiving antenna diameters no additional discrimination is needed for orbital separations larger than 2.8° in order to overcome coordination problems.

With 10 dB of discrimination these values are in the range between 0.7° and 2.3°, depending on the combination of Region 2 BSS network peak e.i.r.p. value and Region 3 FSS network earth station receiving antenna diameter.

With 20 dB of discrimination these values are in the range to 0.4° to 1.6°.

FIGURE A5-13

Needed discrimination for the Region 2 BSS around 175.2°W vs. Region 3 FSS case

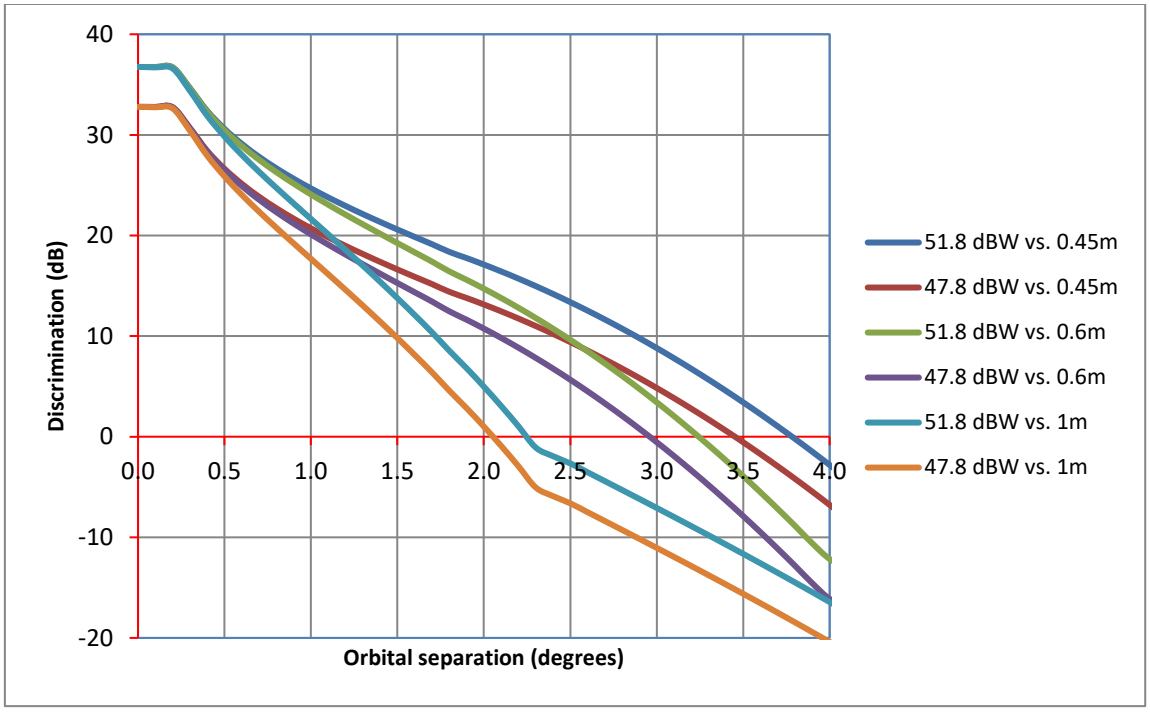


In order to analyse the feasibility of such orbital arc extension in the opposite case of sharing scenario (Region 3 FSS network vs. Region 2 BSS network), technical analyses were done to show necessary additional discrimination needed to be applied by FSS networks in this extended orbital arc in order to overcome coordination problems, taking into account additional off-set gain discrimination of the receiving antenna. The results indicate the corresponding orbital separations at which coordination cases in question would be easily resolvable.

The results of analysis are shown in Fig. A5-14. As the needed discrimination is positive only for orbital separation smaller than 4 degrees, only this part of results is shown in Fig. A5-14.

FIGURE A5-14

Needed discrimination for the Region 3 FSS around 175.2°W vs. Region 2 BSS case



From Fig. A5-14 it is visible that for all applied peak e.i.r.p. values for Region 3 FSS networks and Region 2 BSS representative earth station receiving antenna diameters no additional discrimination is needed for orbital separations bigger than 3.8° in order to overcome coordination problems.

With 10 dB of discrimination these values would be in the range between 1.5° and 2.8°, depending on the combination of interfering peak e.i.r.p. values of Region 3 FSS networks and the representative Region 2 BSS networks earth station receiving antenna diameter. With 20 dB of discrimination these values are between 0.8° and 1.6°.

Due to the fact that FSS networks in Region 3 usually employ lower peak e.i.r.p. values compared to planned BSS networks in Region 2, the sharing situation is more favourable for smaller orbital separations. On the other side, the necessity of protection of small Region 2 BSS receiving earth station antenna of 45 cm makes the sharing situation more difficult for larger orbital separations (>2.5°).

However, by applying 20 dB of discrimination, which could be difficult to achieve, the coordination problem would be minimal for orbital separation larger than 1.5°, except in the cases of maximum peak e.i.r.p. applied for Region 3 FSS networks against BSS networks in Region 2 with very small earth station antenna diameters.

Due to the fact that the orbital arc extension in this particular case would not bring any practical usefulness due to lack of visibility of the American continents, this technical analysis is presented only for information.

4 Study #4: View at the sharing scenario Region 2 BSS vs. Region 1 BSS around 175.2°W

As in the sharing situation covered in § 3.2.5 (Region 2 BSS in the frequency band 12.2-12.5 GHz coexisting with Region 1 BSS), Region 2 BSS networks around 175.2°W coexist also with Region 1 BSS networks operating in the frequency band 12.2–12.5 GHz. So the same question of possible increase in far side lobes of the Region 1 BSS network emerges.

Current minimum orbital separation imposed by Annex 7 between Region 1 and Region 2 BSS networks in this orbital arc is 38.8 degrees (175.2°W – 146°E). This gives the limit of −103.6 dB(W/(m^2 · 27 MHz)) in § 3 of Annex 1 pfd mask for the BSS protection. The same value represents a hard limit specified in section 1 of Annex 1 to Appendix **30** which should never be exceeded by any new BSS List assignment. The same value is incorporated in § 6 of Annex 1 pfd mask for the protection of BSS networks from all new FSS networks. Having that in mind we can conclude that no additional limitation would be needed to prevent the accumulation of additional noise in far side lobes of the receiving BSS antennas.

However, if the above mentioned limiting orbital position would be revised and the corresponding minimum orbital separation between Region 1 and Region 2 BSS networks would be considerably decreased, in such a case additional studies might be needed to address possible future implications of accumulated interference (noise increase) in the far side lobes of Region 1 BSS networks.

5 Study #5: Details of the Region 3 limitations

Planned BSS networks operating over the Region 3 areas use the frequency band 11.7-12.2 GHz. Annex 7 to Appendix **30** of the Radio Regulations does not contain any specific limitation to be applied to the Region 3 planned BSS networks.

The only practical limitation for the Region 3 planned BSS networks stems from the usable elevation angle at orbital positions very far to the west or to the east. The current Region 3 BSS Plan assignments occupy the orbital arc 34°E – 178°W.

Annex 6

Studies on Annex 7 limitation ‘A3a’ (i.e. No assignments in the Regions 1 and 3 List outside specific allowable portions of the orbital arc between 37.2°W and 10°E in the frequency band 11.7-12.2 GHz)

Summary of studies in this Annex are provided in § 11 above of the Report.

1 Intra-service sharing between Regions 1 & 3 BSS networks with antenna size lower than 60 cm and Regions 1 and 3 BSS networks

1.1 Analysis on the use of antenna sizes lower than 60 cm with current A3a limitation

Taking into account the orbital limitations referred to in § 11.1.1, and considering an example where a pair of assignments are having a geocentric separation of 6 degrees, it is possible under the current regulatory framework to implement smaller antenna sizes than the standard 0.60 m antenna size.

In Fig. A6-1, the off-axis antenna gain (following Recommendation ITU-R BO.1213 reference pattern) of antenna sizes 0.60 m and 0.40 m is plotted vs geocentric orbital separation (frequency 11.7 GHz and efficiency of 65%).

FIGURE A6-1

Off-axis antenna gain of antenna dimensions 0.60 m and 0.40 m vs geocentric orbital separation

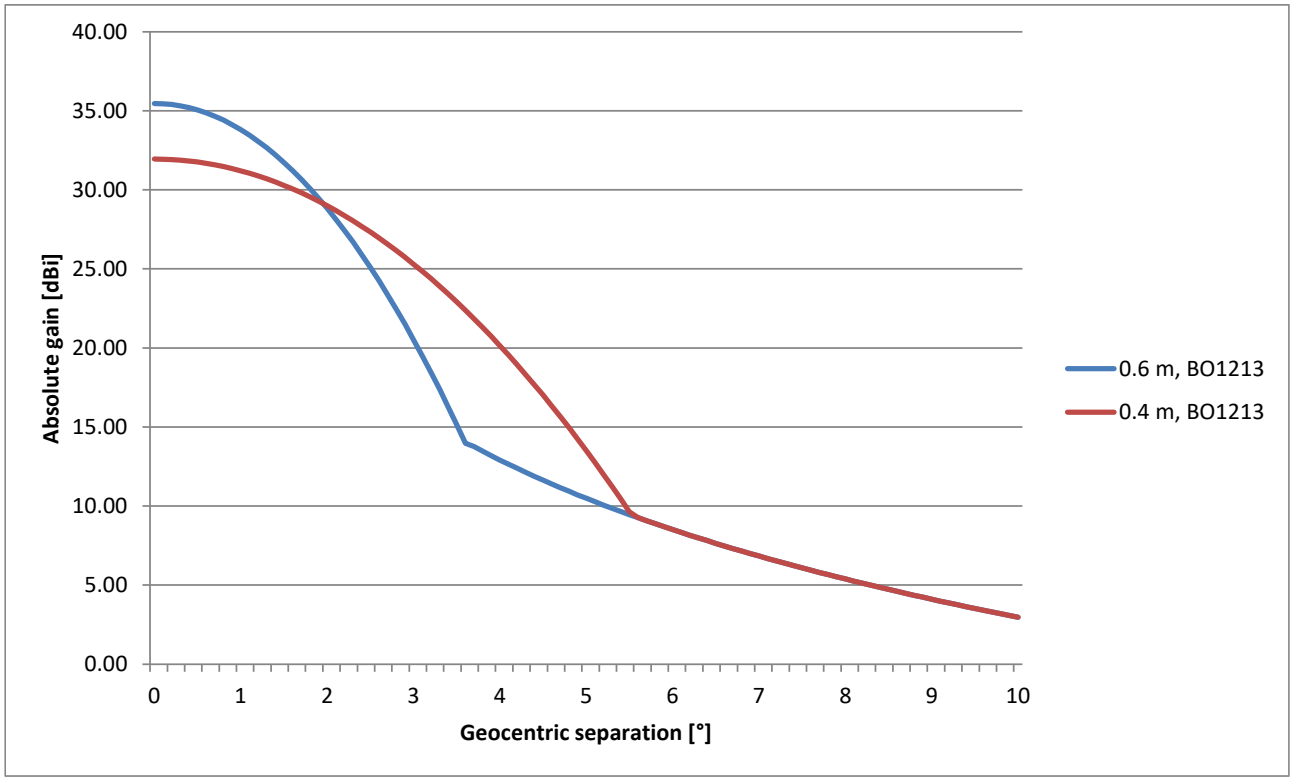


Figure A6-1 shows that the off-axis antenna gain for a 0.40 m antenna is the same as for a 0.60 m antenna for separation angles more than 5.5 degrees. For pairs of networks having orbital separation greater than 5.5°, it may be possible to implement smaller antenna sizes under the umbrella of existing pfd limits in Annex 1 to RR Appendix **30**.

These kinds of implementations are possible under the current regulatory framework, and need to be studied and taken into account when studying possible mechanisms for protection of, and without imposing additional constraints on, assignments in the Plan and the List and the future development of the broadcasting-satellite service within the Plan, and existing and planned fixed-satellite service networks.

1.2 Study #1: Potential impact to assignments having smaller antennas than 60 cm

This study assesses the impact on these assignments in a scenario where WRC-19 decides to remove limitation A3a without additional specific measures.

1.2.1 Overview of the simulation

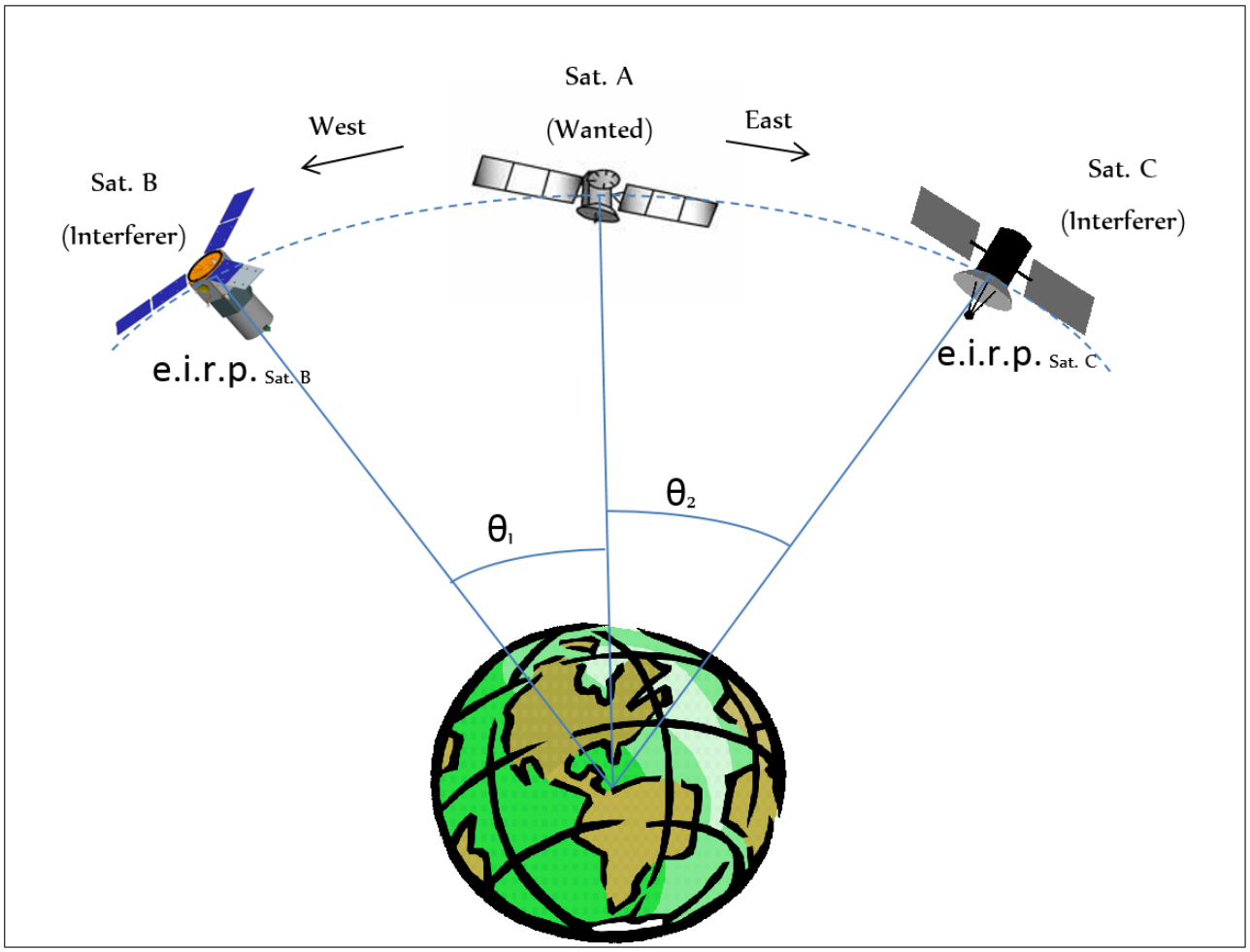
For this analysis (see Fig. A6-2), we considered a wanted satellite A which could be located everywhere within the allowable portions of Table 1 to Annex 7 of RR Appendix **30**. Since the specific overall interference situation in some cases permits to implement antenna sizes smaller than 60 cm, we also assumed that satellite A has implemented earth stations with antenna size of 40 cm. An antenna in the order of this size is considered as being a more attractive than 60 cm to the consumer, mainly since it may be lighter in weight, easier to install and also occupying less space. Further, we considered an interfering satellite B located at a western slot to satellite A and another interfering satellite C located at an eastern slot to satellite A. To simplify the study, only two interfering satellites were considered, recognizing however that the interference will be higher if more than two interfering satellites are to be considered. Further, it was also assumed that satellites B and C could not be located in the same allowable portion of Table 1 to Annex 7 of RR Appendix **30** as

satellite A. For the analysis considering the current Annex 7 limitation for satellites B and C, these satellites are thus located in adjacent allowable portions.

The e.i.r.p. of satellites B and C considered in this analysis is equal to the maximum e.i.r.p. allowable according to the pfd mask of Annex 1 to RR Appendix **30** (see equations (A6-1) and (A6-2)) at a given point. Therefore, we considered the maximum level of interference which could be received by each earth station of Satellite A without triggering the coordination process of Article 4 to RR Appendix **30**.

FIGURE A6-2

Analysis configuration



where:

θ_1: is the geocentric orbital separation angle between Sat. A and Sat. B;

θ_2: is the geocentric orbital separation angle between Sat. A and Sat. C.

and

$$e.i.r.p._{Sat.B} = PFD_{Mask}^{Limit\ 1\ Annex\ 1}(\theta_1) + 162.07\ (dBW/27MHz) \quad \text{(A6-1)}$$

$$e.i.r.p._{Sat.C} = PFD_{Mask}^{Limit\ 1\ Annex\ 1}(\theta_2) + 162.07\ (dBW/27MHz) \quad \text{(A6-2)}$$

where $PFD_{Mask}^{Limit\ 1\ Annex\ 1}$ is the power flux-density limit as a function of geocentric orbital separation angle as given by § 1 in Annex 1 to RR Appendix **30**, and the term *162.07* corresponds to the resulting spread loss at a given earth station at a distance from satellite B or C corresponding to 35786 km.

For each allowable portions of Table 1 to Annex 7 of RR Appendix **30**, an analysis was made considering that satellite A is located at the lower boundary, at the centre and at the upper boundary of each allowable portion of the arc.

For each of the considered orbital positions of satellite A, analysis was performed considering the orbital positions of satellites B and C generating the maximum level of interference towards a given earth station receiving from satellite A.

In order to assess the potential impact to assignments in the Plan and List within the allowable portions of Table 1 to Annex 7 of RR Appendix **30** if limitation A3a on the use of the orbital arc 37.2°W to 10°E is removed by WRC-19, without introducing additional specific measures, first a preliminary analysis was performed considering the current Annex 7 limitation for satellites B and C. Then, a second analysis was performed considering that Table 1 of Annex 7 has been removed.

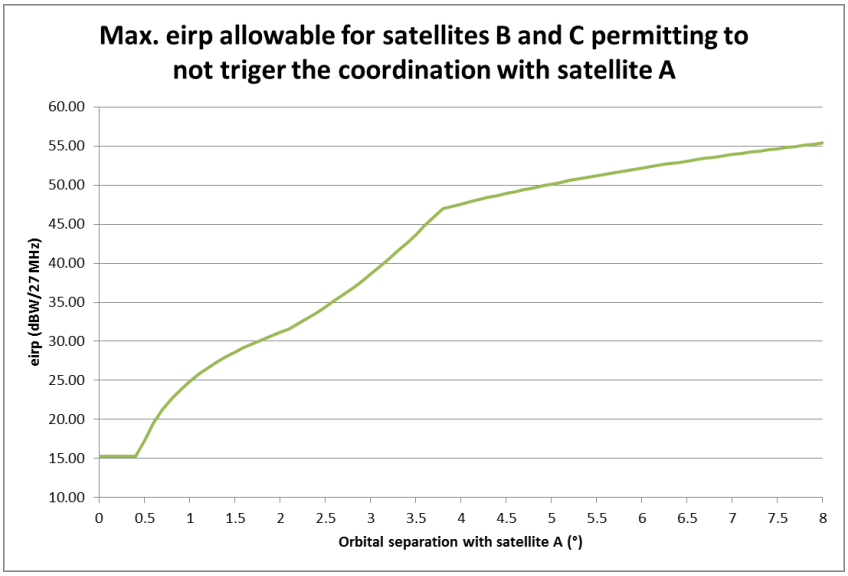
As the antenna discrimination of a given earth station is a function of frequency, these analyses were performed considering transmitted wanted and interfering carriers at 11.7 GHz and at 12.2 GHz in order to study the impact across the frequency band 11.7-12.2 GHz.

1.2.2 Interference level generated by satellites B and C

Figure A6-3 shows the maximum e.i.r.p. allowable for satellites B and C according to the pfd mask in section 1 of Annex 1 to RR Appendix **30** not triggering the coordination process of Article 4 of RR Appendix **30** with satellite A based on equations (A6-1) and (A6-2).

FIGURE A6-3

Max. e.i.r.p. allowable for satellites B and C



The interference level from satellites B or C received by an earth station with antenna size 40 cm is equal to the transmitted e.i.r.p. of satellites B or C plus the off-axis antenna gain of the satellite A earth station (see equations (A6-3) and (A6-4)) in the direction towards satellite B or C.

$$I_{Sat.B} = e.i.r.p._{Sat.B} + G_{Rx}^{40\,cm}(\varphi_1) - L_{FS} \quad \text{(A6-3)}$$

$$I_{Sat.C} = e.i.r.p._{Sat.C} + G_{Rx}^{40\,cm}(\varphi_2) - L_{FS} \quad \text{(A6-4)}$$

where:

φ_1: is the topocentric separation angle between satellite A and satellite B seen from the satellite A earth station

φ_2: is the topocentric separation angle between satellite A and satellite C seen from the satellite A earth station

$G_{Rx}^{40\ cm}(\varphi_1)$: is the receiving off-axis antenna gain of the earth station with antenna size of 40 cm of satellite A in the direction of satellite B

$G_{Rx}^{40\ cm}(\varphi_2)$: is the receiving off-axis antenna gain of the earth station with antenna size of 40 cm of satellite A in the direction of satellite C

L_{FS}: is the free space loss at a distance of 35 786 km.

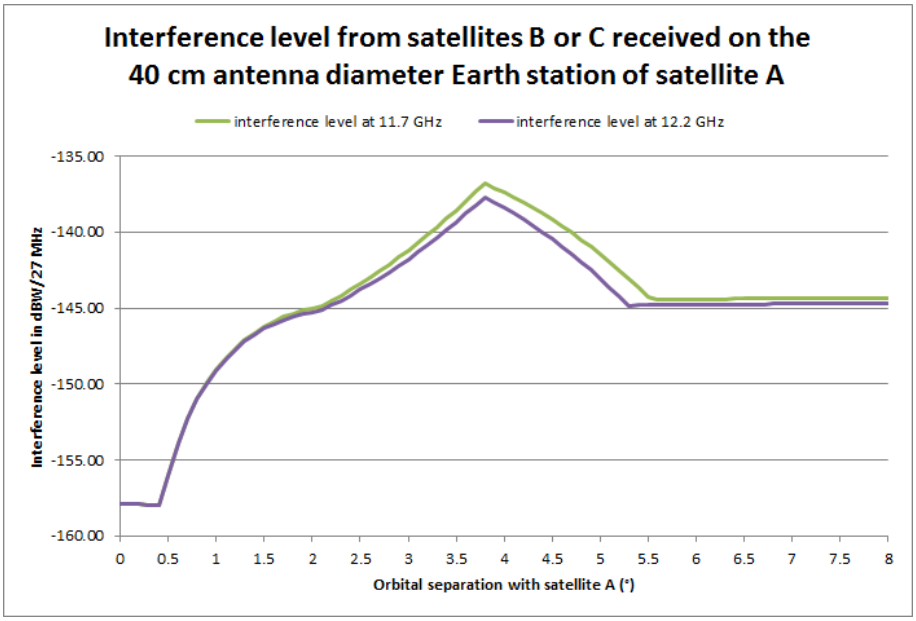
According to Fig. A6-4, the maximum interference level for an earth station with antenna size of 40 cm with an efficiency of 65% considering the maximum e.i.r.p. allowable according to the pfd mask of section 1 of Annex 1 to RR Appendix **30** is observed at an orbital position of 3.8° (i.e. –136.82 dBW/27 MHz at 11.7 GHz and –137.75 dBW/27 MHz at 12.2 GHz).

Therefore, without considering current orbit limitations in Annex 7, the maximum interference received by an earth station with antenna size of 40 cm receiving from satellite A will be when satellites B and C are both located at 3.8° on each side of satellite A. In this configuration, the aggregate interference, using equation (A6-5) below, will be equal to –133.81 dBW/27 MHz for 11.7 GHz and –134.74 dBW/27 MHz for 12.2 GHz.

$$I_{agg} = 10\log\left(10^{I_{Sat.B}/10} + 10^{I_{Sat.C}/10}\right) \quad \text{(A6-5)}$$

FIGURE A6-4

Interference level received by an earth station with antenna size of 40 cm



1.2.3 Analysis results

Figures A6-5 to A6-15 show the analysis results for each allowable portions of Table 1 to Annex 7 of RR Appendix **30** for both frequencies (i.e. 11.7 GHz / 12.2 GHz).

As an example for Fig. A6-5, if satellite A located at 37.2°W is considered, no satellite B could be located further west according to Annex 7 (section A1) and satellite could located within the orbital arc 33.5°W-32.5°W. Therefore, the possible orbital separation between satellites A and C could be between 3.7° and 4.7°. According to Fig. A6-4, the maximum of interference towards satellite A is generated by satellite C if it is located at 3.8° from satellite A.

Hence, this worst case interference at this orbital separation is retained and the level of interference received by an earth station with antenna size 40 cm receiving from satellite A is equal to −136.82 dBW/27 MHz at 11.7 GHz and −137.75 dBW/27 MHz at 12.2 GHz. But as shown in section 3 above, the maximum interference received by an earth station with antenna size 40 cm receiving from satellite A in the case of no orbital limitations in Annex 7 will be equal to −133.81 dBW/27 MHz at 11.7 GHz and −134.74 dBW/27 MHz at 12.2 GHz (i.e. satellites B and C are both located at 3.8° on each side of satellite A). Therefore, for a satellite A located at 37.2°W, a removal of Table 1 of Annex 7, without additional specific measures, the interference that an incumbent is forced to accept would increase by around 3 dB.

If satellite A located at 7°W (Fig. A6-1) is considered, currently adjacent satellites could be located in the arc 14°W-12°W and at 4°W, which would generate an aggregate interference of −139.38 dBW/27 MHz at 12.2 GHz to an earth station with antenna size 40 cm receiving from satellite A. A removal of Table 1 of Annex 7, with the result that adjacent satellites could be both located at 3.8° on each side of satellite A, could in worst case generate an aggregate interference of −134.74 dBW/27 MHz at 12.2 GHz to an earth station with antenna size 40 cm receiving from satellite A. In other words, the level of interference that an incumbent is forced to accept would increase by 4.64 dB.

In some configurations (when satellite A is at 6ºW or 2ºW GSO positions) the increased interference level that an incumbent is forced to accept could be up to 7.85 dB. Therefore, there is a risk that an existing satellite network implementing earth stations with antenna size of 40 cm under the current regulatory regime defined by current orbit limitations in Annex 7, will not be able to continue its operation due to the additional level of interference that an incumbent is forced to accept, unless no additional specific measures are considered.

However, the situation is better with antenna for 33.5ºW, 30ºW and 4.8ºE GSO positions and for antenna size 45 cm.

FIGURE A6-5

Orbital arc 37.2°W to 36°W

Sat. A	Orbital arc	37.2°W to 36°W		
	Orbital position	37.2°W	36.6°W	36°W
Sat. B (Western Pos.)	Orbital arc	No satellite allowable		
	Possible orbital separation with Sat. A	-	-	-
	Worst Interf. orbital separation with Sat. A	-	-	-
Sat. C (Eastern Pos.)	Orbital arc	33.5°W to 32.5°W		
	Possible orbital separation with Sat. A	3.7° to 4.7°	3.1° to 4.1°	2.6° to 3.6°
	Worst Interf. orbital separation with Sat. A	3.8°	3.8°	3.6°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-136.82 / -137.75	-136.82 / -137.75	-137.95 / -138.78
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		3.01 / 3.01	3.01 / 3.01	4.14 / 4.04

FIGURE A6-6

Orbital arc 33.5°W to 32.5°W

Sat. A	Orbital arc	33.5°W to 32.5°W		
	Orbital position	33.5°W	33°W	32.5°W
Sat. B (Western Pos.)	Orbital arc	37.2°W to 36°W		
	Possible orbital separation with Sat. A	2.5° to 3.7°	3° to 4.2°	3.5° to 4.7°
	Worst Interf. orbital separation with Sat. A	3.7°	3.8°	3.8°
Sat. C (Eastern Pos.)	Orbital arc	30°W to 29°W		
	Possible orbital separation with Sat. A	3.5° to 4.5°	3° to 4°	2.5° to 3.5°
	Worst Interf. orbital separation with Sat. A	3.8°	3.8°	3.5°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-134.06 / -134.97	-133.81 / -134.74	-134.59 / -135.45
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		0.25 / 0.23	0.00 / 0.00	0.79 / 0.71

FIGURE A6-7

Orbital arc 30°W to 29°W

Sat. A	Orbital arc	30°W to 29°W		
	Orbital position	30°W	29.5°W	29°W
Sat. B (Western Pos.)	Orbital arc	33.5°W to 32.5°W		
	Possible orbital separation with Sat. A	2.5° to 3.5°	3° to 4°	3.5° to 4.5°
	Worst Interf. orbital separation with Sat. A	3.5°	3.8°	3.8°
Sat. C (Eastern Pos.)	Orbital arc	26°W to 24°W		
	Possible orbital separation with Sat. A	4° to 6°	3.5° to 5.5°	3° to 5°
	Worst Interf. orbital separation with Sat. A	4°	3.8°	3.8°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-134.91 / -135.83	-133.81 / -134.74	-133.81 / -134.74
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		1.1 / 1.1	0.00 / 0.00	0.00 / 0.00

FIGURE A6-8

Orbital arc 26°W to 24°W

Sat. A	Orbital arc	26°W to 24°W		
	Orbital position	26°W	25°W	24°W
Sat. B (Western Pos.)	Orbital arc	30°W to 29°W		
	Possible orbital separation with Sat. A	3° to 4°	4° to 5°	5° to 6°
	Worst Interf. orbital separation with Sat. A	3.8°	4°	5°
Sat. C (Eastern Pos.)	Orbital arc	20°W to 18°W		
	Possible orbital separation with Sat. A	6° to 8°	5° to 7°	4° to 6°
	Worst Interf. orbital separation with Sat. A	8°	5°	4°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-136.11 / -136.95	-135.96 / -137.14	-135.96 / -137.14
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		2.31 / 2.21	2.16 / 2.4	2.16 / 2.4

FIGURE A6-9

Orbital arc 20°W to 18°W

Sat. A	Orbital arc	20°W to 18°W		
	Orbital position	20°W	19°W	18°W
Sat. B (Western Pos.)	Orbital arc	26°W to 24°W		
	Possible orbital separation with Sat. A	4° to 6°	5° to 7°	6° to 8°
	Worst Interf. orbital separation with Sat. A	4°	5°	8°
Sat. C (Eastern Pos.)	Orbital arc	14°W to 12°W		
	Possible orbital separation with Sat. A	6° to 8°	5° to 7°	4° to 6°
	Worst Interf. orbital separation with Sat. A	8°	5°	4°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-136.59 / -137.49	-138.47 / -140.08	-136.59 / -137.49
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		2.79 / 2.75	4.66 / 5.35	2.79 / 2.75

FIGURE A6-10

Orbital arc 14°W to 12°W

Sat. A	Orbital arc	14°W to 12°W		
	Orbital position	14°W	13°W	12°W
Sat. B (Western Pos.)	Orbital arc	20°W to 18°W		
	Possible orbital separation with Sat. A	4° to 6°	5° to 7°	6° to 8°
	Worst Interf. orbital separation with Sat. A	4°	5°	8°
Sat. C (Eastern Pos.)	Orbital arc	8°W to 6°W		
	Possible orbital separation with Sat. A	6° to 8°	5° to 7°	4° to 6°
	Worst Interf. orbital separation with Sat. A	8°	5°	4°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-136.59 / -137.49	-138.47 / -140.08	-136.59 / -137.49
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		2.79 / 2.75	4.66 / 5.35	2.79 / 2.75

FIGURE A6-11

Orbital arc 8°W to 6°W

Sat. A	Orbital arc	8°W to 6°W		
	Orbital position	8°W	7°W	6°W
Sat. B (Western Pos.)	Orbital arc	14°W to 12°W		
	Possible orbital separation with Sat. A	4° to 6°	5° to 7°	6° to 8°
	Worst Interf. orbital separation with Sat. A	4°	5°	8°
Sat. C (Eastern Pos.)	Orbital arc	4°W		
	Possible orbital separation with Sat. A	4°	3°	2°
	Worst Interf. orbital separation with Sat. A	4°	3°	2°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-134.37 / -135.4	-138.33 / -139.38	-141.65 / -141.96
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		0.57 / 0.66	4.53 / 4.64	7.85 / 7.22

FIGURE A6-12

Orbital position 4°W

Sat. A	Orbital arc	4°W
	Orbital position	4°W
Sat. B (Western Pos.)	Orbital arc	8°W to 6°W
	Possible orbital separation with Sat. A	2° to 4°
	Worst Interf. orbital separation with Sat. A	3.8°
Sat. C (Eastern Pos.)	Orbital arc	2°W to 0°E
	Possible orbital separation with Sat. A	2° to 4°
	Worst Interf. orbital separation with Sat. A	3.8°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-133.81 / -134.74
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		0.00 / 0.00

FIGURE A6-13

Orbital arc 2°W to 0°E

Sat. A	Orbital arc	2°W to 0°E		
	Orbital position	2°W	1°W	0°E
Sat. B (Western Pos.)	Orbital arc	4°W		
	Possible orbital separation with Sat. A	2°	3°	4°
	Worst Interf. orbital separation with Sat. A	2°	3°	4°
Sat. C (Eastern Pos.)	Orbital arc	4°E to 6°E		
	Possible orbital separation with Sat. A	6° to 8°	5° to 7°	4° to 6°
	Worst Interf. orbital separation with Sat. A	8°	5°	4°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-141.65 / -141.96	-138.33 / -139.38	-134.37 / -135.4
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		7.85 / 7.22	4.53 / 4.64	0.57 / 0.66

FIGURE A6-14

Orbital arc 4°E to 6°E

Sat. A	Orbital arc	4°E to 6°E		
	Orbital position	4°E	5°E	6°E
Sat. B (Western Pos.)	Orbital arc	2°W to 0°E		
	Possible orbital separation with Sat. A	4° to 6°	5° to 7°	6° to 8°
	Worst Interf. orbital separation with Sat. A	4°	5°	8°
Sat. C (Eastern Pos.)	Orbital arc	9°E		
	Possible orbital separation with Sat. A	5°	4°	3°
	Worst Interf. orbital separation with Sat. A	5°	4°	3°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-135.96 / -137.14	-135.96 / -137.14	-139.48 / -139.99
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74	-133.81 / -134.74	-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		2.16 / 2.4	2.16 / 2.4	5.67 / 5.25

FIGURE A6-15

Orbital position 9°E

Sat. A	Orbital arc	9°E
	Orbital position	9°E
Sat. B (Western Pos.)	Orbital arc	4°E to 6°E
	Possible orbital separation with Sat. A	3° to 5°
	Worst Interf. orbital separation with Sat. A	3.8°
Sat. C (Eastern Pos.)	Orbital arc	greater than or equal to 10°
	Possible orbital separation with Sat. A	1° to 8°
	Worst Interf. orbital separation with Sat. A	3.8°
Max. interference (11.7/12.2 GHz) towards Sat. A considering current Annex 7 limitation (dB)		-133.81 / -134.74
Max. interference (11.7/12.2 GHz) towards Sat. A without Annex 7 limitation (dB)		-133.81 / -134.74
Additional interference (11.7/12.2 GHz) towards Sat. A (dB)		0.00 / 0.00

Figure A6-16 contains a summary of the potential additional interference that an incumbent is forced to accept, for each possible slot in Table 1 of Annex 7 of RR Appendix **30** for a network operating with earth stations with antenna size 40 cm, if current orbit limitations in Annex 7 are removed without additional specific measures.

FIGURE A6-16

Analysis overview

Orbital arc	37.2°W to 36°W	33.5°W to 32.5°W	30°W to 29°W	26°W to 24°W	20°W to 18°W	14°W to 12°W	8°W to 6°W	4°W	2°W to 0°E	4°E to 6°E	9°E
Additional interference towards Sat. A (dB)	Up to 4.14 dB	Up to 0.79 dB	Up to 1.1 dB	Up to 2.4 dB	Up to 5.35 dB	Up to 5.35 dB	Up to 7.85 dB	0 dB	Up to 7.85 dB	Up to 5.67 dB	0 dB

1.3 Study #2: pfd mask to protect antenna size 40 cm

The results in § 1.2 show that there will be an increase of interference levels to these specific BSS networks if no additional specific measures are adopted.

A review of SPS database of BR IFIC 2836 shows that in the arc 37.2°W-10°E there are four satellite network filings submitted with antenna sizes smaller than 0.60 m, in three different orbital locations. As of May 2019, three of them are implemented.

1.3.1 Derivation of pfd mask for antenna size 40 cm

The current pfd limits in section 1, Annex 1 to RR Appendix **30** are based on parameters contained in Annex 6 in the same appendix. A summary of the essential parameters are presented in Table A6-1 below.

TABLE A6-1

Summary of essential parameters in Annex 6 to Appendix 30

Receive earth station antenna diameter, *D*	0.60	0.80	1.20	2.40	[m]
Receive earth station reference antenna pattern	BO.1213	BO.1213	BO.1213	BO.1213	[-]
Receive earth station noise temperature, T_e	110	125	150	150	[K]
Total link noise temperature, T_s	174	198	238	238	[K]
Frequency, *f*	11.7	11.7	11.7	11.7	[GHz]
Antenna efficiency, η	65	65	65	65	[%]
Allowable relative increase in receive link noise, $\Delta T/T$	6	6	6	6	[%]
Reference bandwidth, b_{rf}	27	27	27	27	[MHz]
Boltzmann's constant, *k*	1.38E-23	1.38E-23	1.38E-23	1.38E-23	[J/K]
Gain for a 1 m^2 effective aperture, G_m	42.81	42.81	42.81	42.81	[dBi/m^2]

According to Annex 6 to Appendix **30**, the allowable interfering power flux density, $pfd_{all}(\theta)$, for a given orbital separation θ is calculated using the following expression:

$$PFD_{all}(\theta) = 10\log\left(\Delta T/T\right) + 10\log\left(kT_s b_{rf}\right) + G_m - G_a(\varphi) \qquad \text{(A6-6)}$$

Where φ is the topocentric angle (degrees) between the interfering and the wanted satellite, as defined in Annex 1 of Appendix **8**, and $G_a(\varphi)$ is the receive antenna gain for topocentric angle of φ.

In Annex 6 to RR Appendix **30**, in addition to the parameters in Table A6-1 above, parameters for a 0.45 m antenna are also given. A 0.40 m antenna would have the same noise characteristics as the 0.45 m antenna and 0.60 m antenna. A summary table with parameters for an earth station with 0.40 m antenna size is shown in Table A6-2:

TABLE A6-2

Parameters for an earth station with antenna size of 0.40 m

Receive earth station antenna diameter, D	0.4	[m]
Receive earth station reference antenna pattern	BO.1213	[-]
Receive earth station noise temperature, T_e	110	[K]
Total link noise temperature, T_s	174	[K]
Frequency, f	11.7	[GHz]
Antenna efficiency, η	65	[%]
Allowable relative increase in receive link noise, $\Delta T/T$	6	[%]
Reference bandwidth, b_{rf}	27	[MHz]
Boltzmann's constant, k	1.38E-23	[J/K]
Gain for a 1 m^2 effective aperture, G_m	42.81	[dBi/m^2]

Applying equation (A6-6) for a 0.40 m antenna size and comparing the results with the results for a 0.60 m antenna size as well as the pfd limits of section 1, Annex 1 to RR Appendix **30**, the following results are obtained:

FIGURE A6-17

Results for PFD_{all} for earth station antenna size 0.40 m

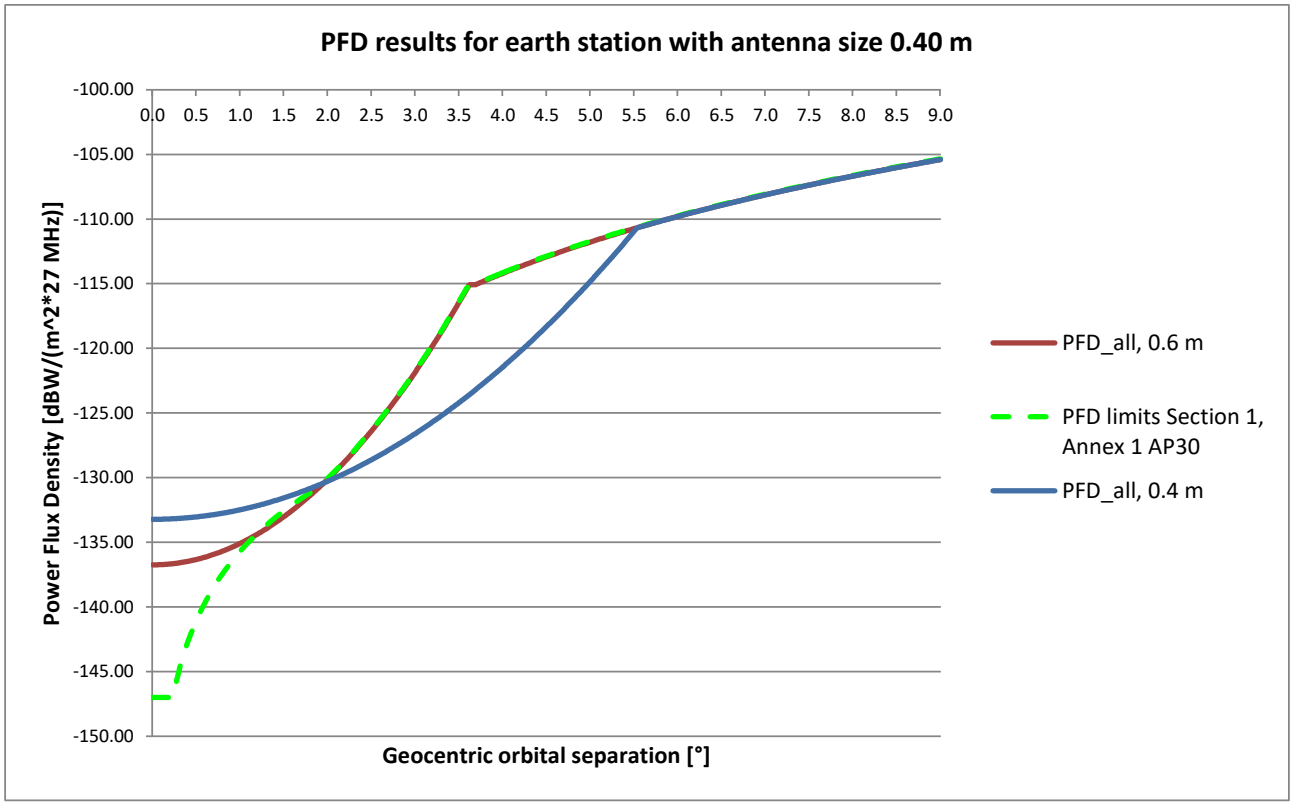


Figure A6-17 suggests that the current pfd limit is suitable for an earth station with antenna size of 0.40 m for geocentric separations of 0° to 2.0° and 5.5° to 9.0° but a modification is needed between 2.0° and 5.5°. A more accurate comparison suggests between 2.00° and 5.54°.

The PFD_{all} for a 0.40 m antenna in the range 2.00° to 5.54° can be written as follows:

$$PFD_{all}(2.00° \leq \theta < 5.54°) = -133.2 + 0.74 \cdot \theta^2 \qquad \text{(A6-7)}$$

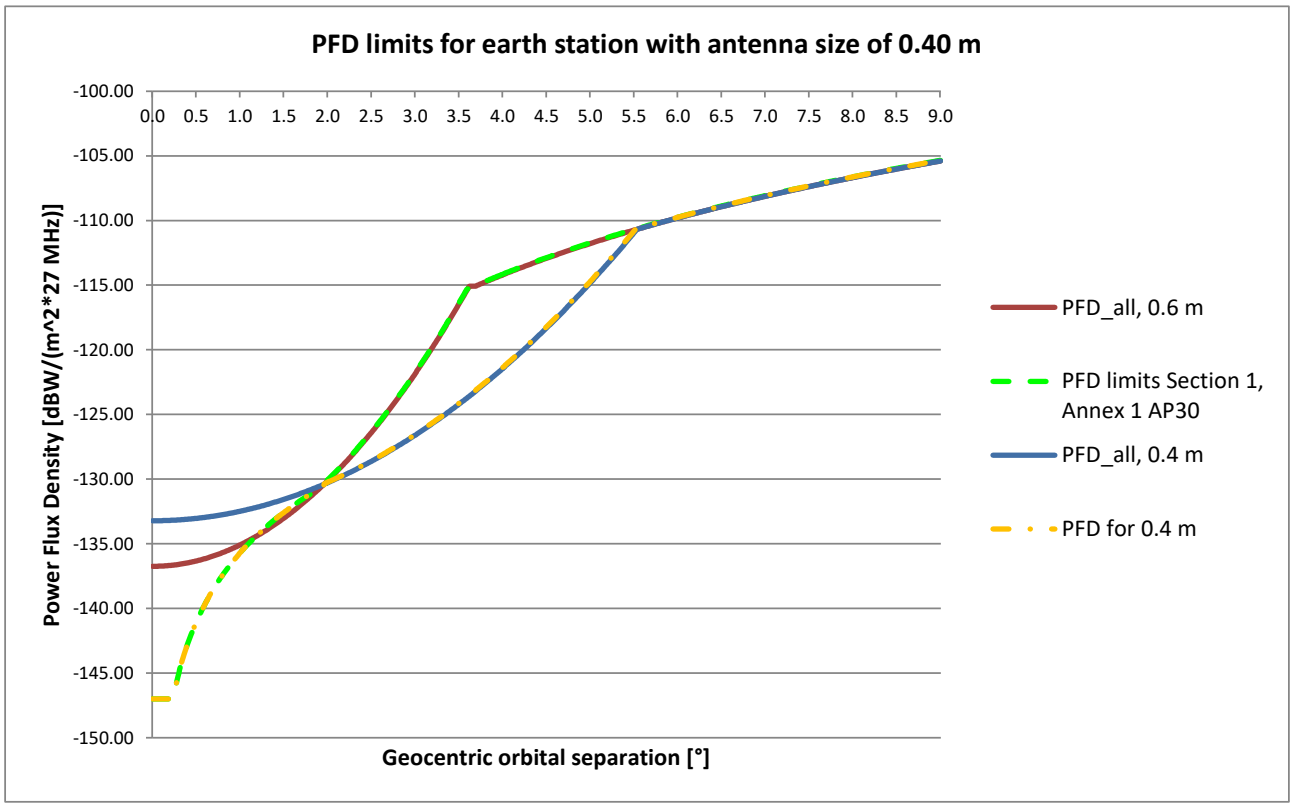
The pfd limit in section 1 of Annex 1 to Appendix **30** also taking into account a 0.40 m antenna is therefore written as follows:

–147	dB(W/(m^2 · 27 MHz))	for 0° ≤ θ < 0.23°
–135.7 + 17.74 log θ	dB(W/(m^2 · 27 MHz))	for 0.23° ≤ θ < 2.00°
–133.2 + 0.74 θ^2	dB(W/(m^2 · 27 MHz))	for 2.00° ≤ θ < 5.54°
–129.2 + 25 log θ	dB(W/(m^2 · 27 MHz))	for 5.54° ≤ θ < 9°

Figure A6-18 shows the above pfd mask together with the results in Fig. A6-17 for verification and illustration.

FIGURE A6-18

Verification of pfd mask for an earth station with antenna size of 0.40 m



1.4 Study #3: assessment of the existing levels of protection of receiving stations with small antennas (40 cm) and current regulatory framework allowed to implement networks, using antennas smaller than 60 cm

1.4.1 Introduction

In accordance with Annex 1 of RR Appendix **30** one of the conditions determining the need for coordination of Region 1 or 3 BSS network is the pfd mask provided in Annex 1 section 1a), this mask was determined by setting at 6% the allowable relative noise increase ($\Delta T/T$) for the earth stations characteristics specified in item 2 of Annex 6 to RR Appendix **30**, including antennas with a diameter of 60 cm.

It should be noted that in revising Plan for broadcasting-satellite service at WRC-97, the minimum receiving antenna diameter was such that the half power beamwidth was 2.86°, i.e. antenna size 60 cm with the absolute gain (dBi) patterns given in Recommendation ITU-R BO.1213.

As noted in § 11.2, administrations under current orbital position limitations and by filing assignments to such orbital separations where envelopes of the antenna pattern for 40 cm and 60 cm are the same, can implement smaller antenna sizes than 60 cm.

The purpose of this study is to assess the existing levels of protection receiving stations with small antennas, in particular antenna size of 40 cm and to examine to what extent the current regulatory framework allows to implement networks, using antennas smaller than 60 cm, while maintaining the same level of protection as defined by Annex 1 (section 1) i.e. at the level $\Delta T/T$=6%.

1.4.2 Allowable level of interference

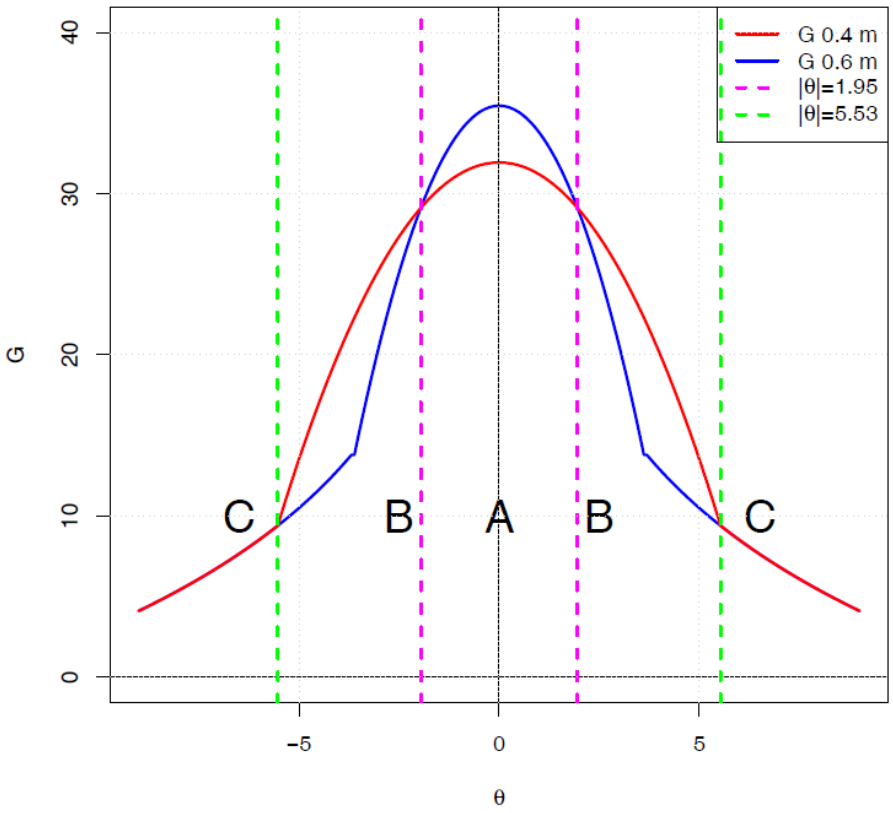
Section 1 of Annex 1 to RR Appendix **30** defines limits for the interference (pfd mask) into frequency assignments at any test point within the service area associated with frequency assignments in the Plan or in the List, wherein there is no need in coordination, i.e. the interference is allowable. In this case, we consider that if the condition in relation pfd limit is met, the assignment is not considered as being affected and is protected at the allowable level (6%). Annex 1 pfd values were identified, including antenna size of 60 cm, with reference antenna pattern in accordance with Recommendation ITU-R BO.1213 and, based on the protection criterion of protection $\Delta T/T$ = 6%.

It should be noted that in order to determine the need of coordination with frequency assignments section 1 of Annex 1 regulates limit for interference into frequency assignment only, for a single interfering station, and it offers no assumptions and comments about the impacts of two or more interfering sources from several interfering space stations.

Figure A6-19 shows the plot of off-axis antenna gain for antenna sizes 40 cm and 60 cm vs geocentric orbital separation (reference pattern in accordance with Recommendation ITU-R BO.1213). It illustrates what is meant by availability for antennas smaller than 60 cm size of the same protection as for antennas of 60 cm and location of not allowable portions of orbital arc.

In ideal case such protection for smaller than 60 cm antenna sizes is assured in case of existence of not allowable portion of arc at orbital separations where small antenna has smaller selectivity than antenna 60 cm size (Fig. A6-19, sections B-C, C-B) and adjacent allowable portion is at the orbital separation from point A equal or more than separation when antenna gain of 40 cm antenna is the same as for 60 cm antenna. For the considered 40 cm antenna size it plots the arc of the GSO at the distance (orbital separation) from the positions concerned from 0ºдо, about 1.95º and ~5.5°.

FIGURE A6-19



where

A: GSO position of wanted satellite where small antenna is used;

B–A−B: GSO section with protection;

C−B and B–C: not allowed portions of orbital arc, coincide with non-securable section (in ideal case).

Orbital separations more than |C|: protected GSO orbital arc sections.

When placing a new network on orbital separations from satellite A equal to or more than “C”, the network that meets Annex 1 pfd mask, does not cause to the earth station with a small antenna receiving from satellite A interference that exceeds the permissible value. When placing this new network B-C or/and C-B the interference to satellite A will exceed the permissible value, these orbital arc sections are hereinafter called non-securable.

Thus, it is clear that for this example, in case of elimination of orbital limitation on the deployment of new network in the arc sections B-C and/or C-B the newcomer network, even if it meets Annex 1 pfd mask, will cause to the earth station of the network at orbital position *t* A interference that exceeds the permissible one. It is obvious that in case that earth station of network A uses antenna with a diameter of 60 cm, the interference caused by network that meets Annex 1 pfd mask will be at an permissible level.

If the allowable orbital arc portion partially or completely coincides with sections B-C and/or C-B the level of interference from the network matching the mask will exceed the permissible, and the network at point A is obliged to accept them.

Thus, protection at 6% level of receiving earth stations with small antennas is provided by the Annex 1 pfd mask from space stations in adjacent allowable portions of GSO orbital arc, only when the "non-securable section" of arc is fully (100%) coincides with not allowable portion of GSO arc, i.e. the allowable portion or part of it does not have intersections with non-securable section.

It may be defined, using the description of antenna pattern from Recommendation ITU-R BO.1213 for antennas of 60 cm and 40 cm sizes, respectively, that conditions of obtaining the same protection for small antenna as for station with antenna of 60 cm size provided for the antennas of 40 cm size starting with orbital separations more than ~5.5º (orbital separation equal to C on Fig. A6-19) and less than ~1.95º (point B, Fig. A6-19) and for antennas of 45 cm size – starting with orbital arc separations more than since ~1.85° and less than ~4.9°.

1.4.3 The methodology used

As in previous sections, we assessed the interference level caused to the earth receiving station using a small antenna, in the case when e.i.r.p. levels of interfering space station meet the Annex 1 pfd mask, i.e. interference is "allowable" by Annex 1. Figures A6-20 and A6-21 show the level of this "allowable" interference as a function of geocentric orbital separation (θ) for antenna sizes of 40 cm and 45 cm accordingly. These Figures also show the corresponding Δ*T*/*T* values (see right axis), and antenna envelopes (dotted line). Calculations were carried out according to the known equations:

$$I(\theta) = PFD_{incompliancewith\ Annex\ 1}(\theta) + 162.07 + G_{smallantenna}(\varphi) - L, \text{ (dBW/27 MHz)}$$

where:

$pfd_{incompliance\ withAnnex\ 1}(\theta)$: the power-flux density limit as a function of geocentric orbital separation (θ), (values - in accordance with Annex 1 (section 1) to RR Appendix **30)**

$G_{small\ antenna}(\varphi)$: receiving off-axis antenna gain of the earth station with antenna size of 40 cm in the direction of satellite in the adjacent allowable orbital arc portion

φ: topocentric separation angle between wanted satellite and interfering satellite in the adjacent allowable orbital arc portion seen from the wanted satellite earth station

162.07: resulting spread loss at a given earth station at a distance from satellite corresponding to d=35 786 km)

L: free space loss for frequency *f* and distance *d*.

Other parameters used in the calculations:

Δ*T*/*T*: allowable relative increase in receiver link noise (for permissible interference Δ*T*/*T*= 6%)

K: Boltzmann's constant (1.38×10^{-23}) (J/K)

T: total receive link noise temperature (K) (174K)

Δ*F*: reference bandwidth (27 MHz in Regions 1 and 3)

Calculations of Δ*T*/*T* values versus orbital separation were performed for antenna of 40 cm size;

The analysis was performed for frequency=11.7 MHz.

BSS earth station antenna: is compliant with the antenna pattern specified in Recommendation ITU-R BO.1213.

FIGURE A6-20

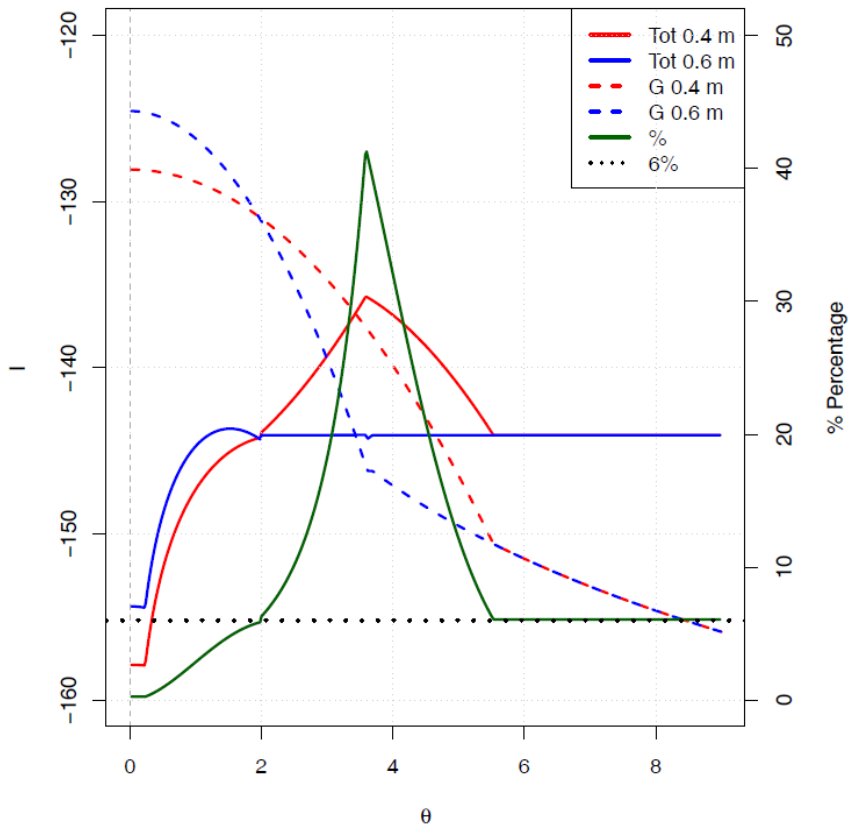
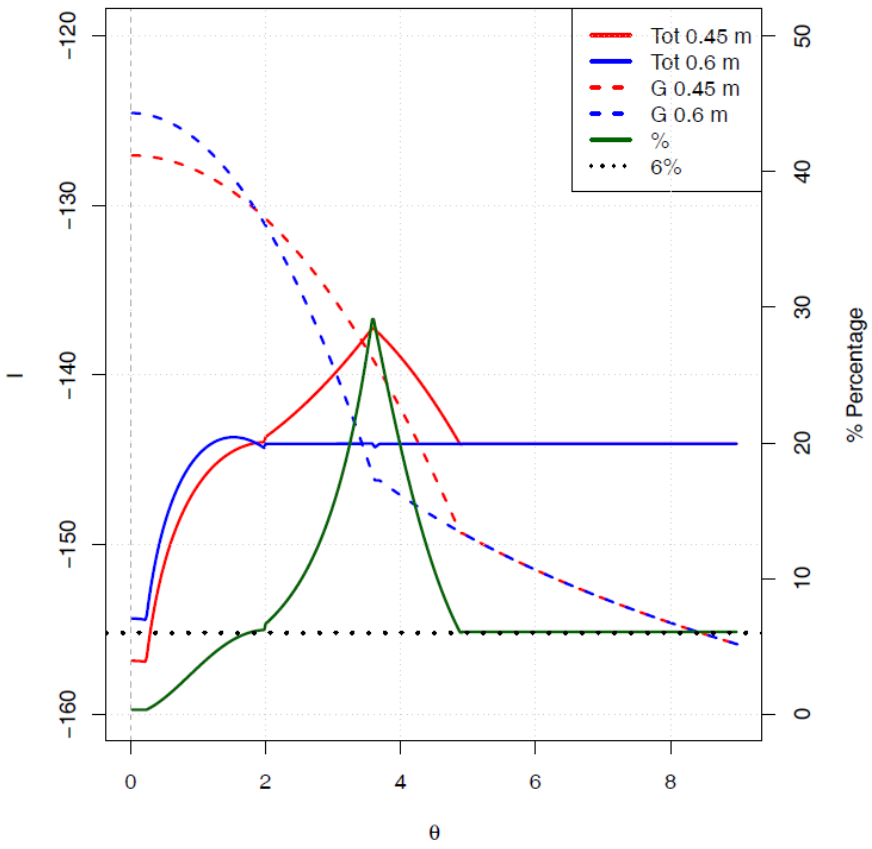


FIGURE A6-21



1.4.4 The detection and estimation of location of the “non-securable” GSO orbital arc sections to earth stations with small antennas under the existing division of the arc from 37.2ºW to 10ºE on allowable and not allowable portions

Further, in Tables A6-3 to A6-13 reviewed all the existing allowable portions of the GSO arc (Table 1 Annex 7 of RR Appendix **30**), for these portions were determined the orbital arc segments, which have no protection (correspond to sections B−C and C−B, Fig. A6-19) and then assessed the overlapping of these "non-securable" sections with adjacent (Western and Eastern) allowed/not allowed portions of the GSO arc. I.e. is considered the alignment of these sections. Analysis of availability of intersection of non-securable sections (on the West and East of considered allowable portion of GSO arc) with allowable is presented for start and end points of the considered section of the arc.

In all the considered GSO arc segments is shown plotted, versus the geocentric orbital separation between satellites, of the value of "allowable" by Annex 1 interference, which shall accept earth station using antenna of 40 cm size, the graph also shows the dependence of $\Delta T/T$. Curves are presented for the start and end points of the allowable portion under consideration. For clarity, on the graphs allowed (adjacent to the arc under consideration) portions in accordance with Annex 7 parts of the GSO arc shown by shading. The graphs allow to estimate possible under the current regulatory framework, the levels of interference and value of $\Delta T/T$, which will have to accept station with a small antenna in the case of submissions for frequency assignments in these adjacent allowable GSO arc portions.

1.4.5 Portions of GSO arc where there is no protection of stations, using antennas of 40 cm size, and their mutual arrangement with the adjacent allowable portions of orbital arc, the degree of intersection

Tables A6-3A to A6-13B show estimated availability and the degree of intersection of allowable and non-securable portions of orbital arc, accurate intersection could be seen on the appropriate Figures showing the dependence of allowable be Annex 1 value of interference (for antenna of 40 cm size) versus orbital separation.

1.4.5.1 Consideration for allowable portion of GSO orbital arc [37.2, 36]W

For western adjacent allowable portion of the orbital arc

TABLE A6-3A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[37.2, 36]W	37.2ºW	[43.7, 39.2]W	–	–	∩=0%
	36ºW	[41.5, 38]W		–	∩=0%

As starting from the position 37.2 W to the West, is the not allowable portion of the GSO arc, it can be argued that with the elimination of this limitation networks meets the Annex 1 pfd mask, which can be placed in this GSJ section including section, where there is no protection, can create interference that exceeds the permissible value ($\Delta T/T$ = 6%) that a network with small antenna at the site [37.2, 36]W will be obliged to accept.

For eastern adjacent allowable portion of the orbital arc

TABLE A6-3B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[37.2, 36]W	37.2ºW	[35.2, 31.7]W	[33.5, 32.5]W	[33.5, 32.5]W⊂[35.2, 31.7]W	∩=100%
	36ºW	[34, 30.5]W		[33.5, 32.5]W⊂[34, 30.5]W	∩=100%

As can be seen from the table adjacent to [37.2, 36]W Eastern allowed orbital arc portion wholly intersects with non-securable section (section B-C in Fig. A6-19), i.e. in this case, the protection of assignments with an antenna of 40 cm size at 6% is not provided from the network corresponding to Annex 1 pfd mask, and filed in all over the adjacent Eastern allowable arc portion; i.e. placed in the adjacent allowable portion space station will cause interference which exceeds which exceeds the allowable criterion ($\Delta T/T$ = 6%), and which the station with small antenna in allowable portion [33.5, 32.5]W is obliged to accept, as is in accordance with Annex 1 it is deemed unaffected.

Below in the graphs (Figs A6-22A and A6-22B) for the portion of GSO arc, including the adjacent Western and Eastern allowable portions is shown versus orbital separation valid to Annex 1 level of interference to earth stations with an antenna diameter of 40 cm, i.e. the interference level where network is not considered to be affected, i.e. those levels of interference, which is currently under the existing provisions of Annex 7 station with small antenna may receive and shall accept. In the graphs for clarity adjacent allowable for filing networks portions is shown with shading. Similarly, for the graphs in § 1.4.5.2-1.4.5.11.

Dependence (Figs A6-22A and A6-22B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [37.2, 36]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-22A

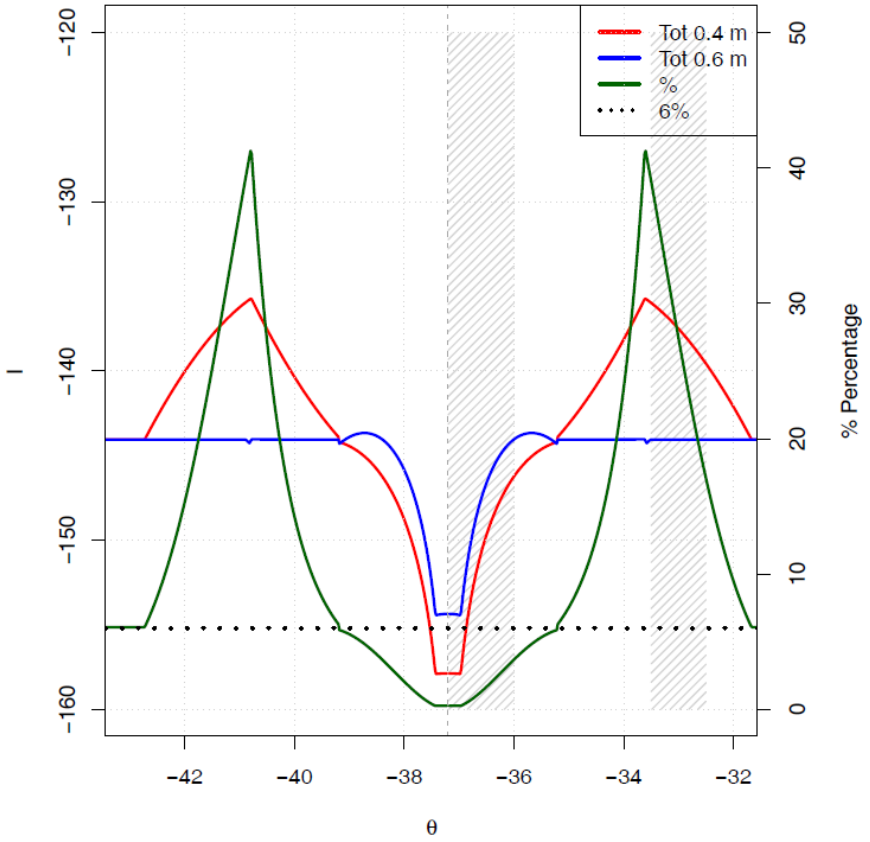
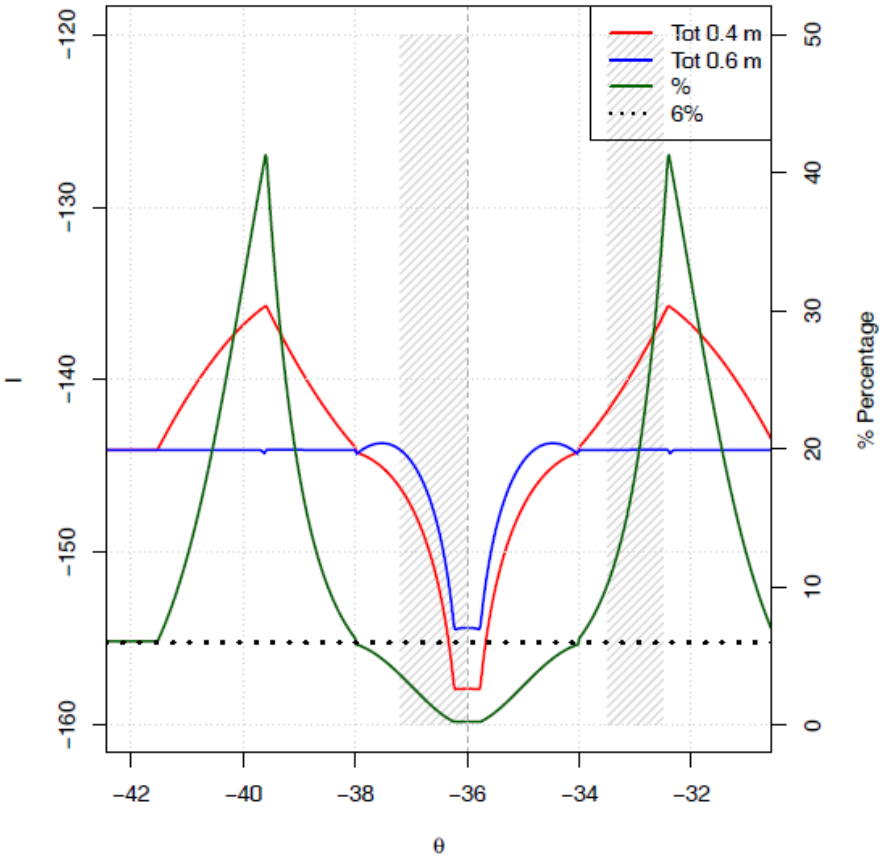


FIGURE A6-22B



Figures show that Eastern allowable arc portion as a whole falls into the “non-securable section” for all points of the considered arc portion [37.2, 36]W, and for a number of positions of considered portion interference from networks in the Eastern section will be maximal, the maximum value $\Delta T/T$ = ~41%, i.e. when placing a new network in any part of the Eastern arc portion is allowed to cause interference to stations with small antenna (40 cm), which exceeds the permissible value $\Delta T/T$ = 6%. The elimination of limitation on the deployment of networks Western than −37.2 W, allow to place new networks to positions that could fall to non-securable section, but the value of caused interference will not be more than value of interference, which currently can be created by placing network in the Eastern allowed arc portion.

1.4.5.2 Consideration for allowable portion of GSO orbital arc [33.5, 32.5]W

For western adjacent allowable portion of the orbital arc

TABLE A6-4A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[33.5, 32.5]W	33.5ºW	[39, 35.5]W	[37.2, 36]W	[37.2, 36]W⊂[39, 35.5]W	∩=100%
	32.5ºW	[38, 34.5]W		[37.2, 36]W⊂[38, 34.5]W	∩=100%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-4B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[33.5, 32.5]W	33.5ºW	[31.5, 28]W	[30, 29]W	[30, 29]W⊂[31.5, 28]W	∩=100%
	32.5ºW	[30.5, 27]W		[30, 29]W⊂[38, 34.5]W	∩=100%

As can be seen from the Tables both adjacent to the [33.5, 32.5]W allowed arc portions as a whole fall into the non-securable sections of the GSO arc (corresponding to sections C−B, B−C in Fig. A6-19), i.e. in this case, the protection of assignments with an antenna diameter of 40 cm at 6% from networks in compliance with Annex 1 is not provided. Filed in both allowable adjacent portions networks will create interference that exceeds the permissible value of $\Delta T/T$ = 6%, and which the network in arc portion [33.5, 32.5]W is obliged to accept because in accordance with the Annex 1 criterion it is deemed unaffected. Both the adjacent allowed arc portion for any point of the interval [33.5, 32.5]W entirely are in "non-securable" sections. For [33.5, 32.5]W possible the maximum value $\Delta T/T$ = ~41%.

Dependence (Figs A6-23A and A6-23B) of “allowed” by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [33.5, 32.5]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-23A

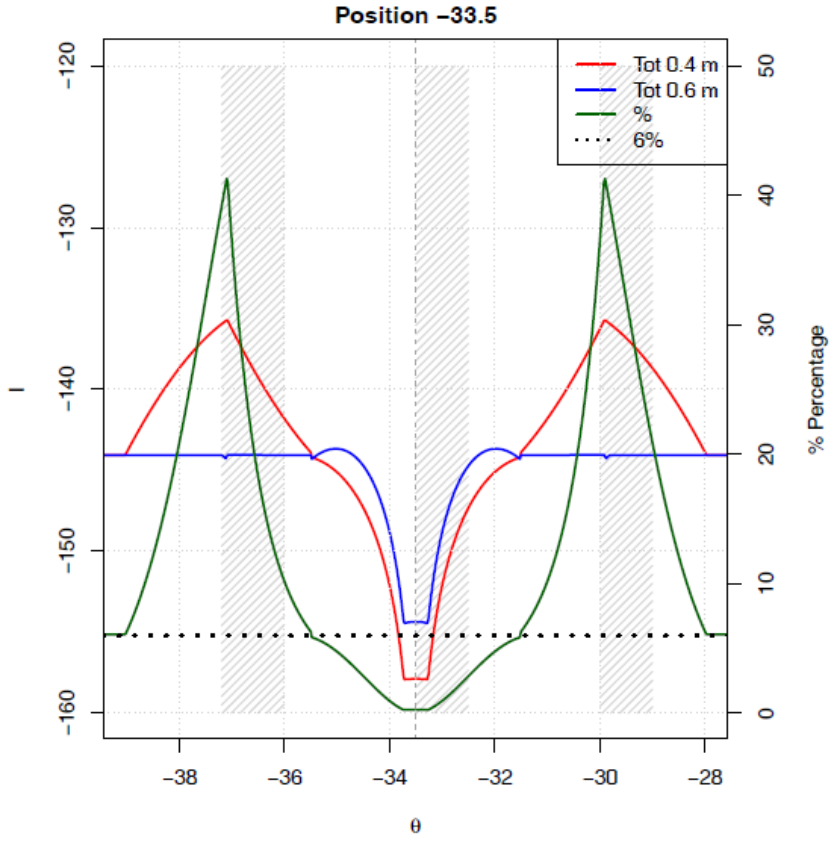
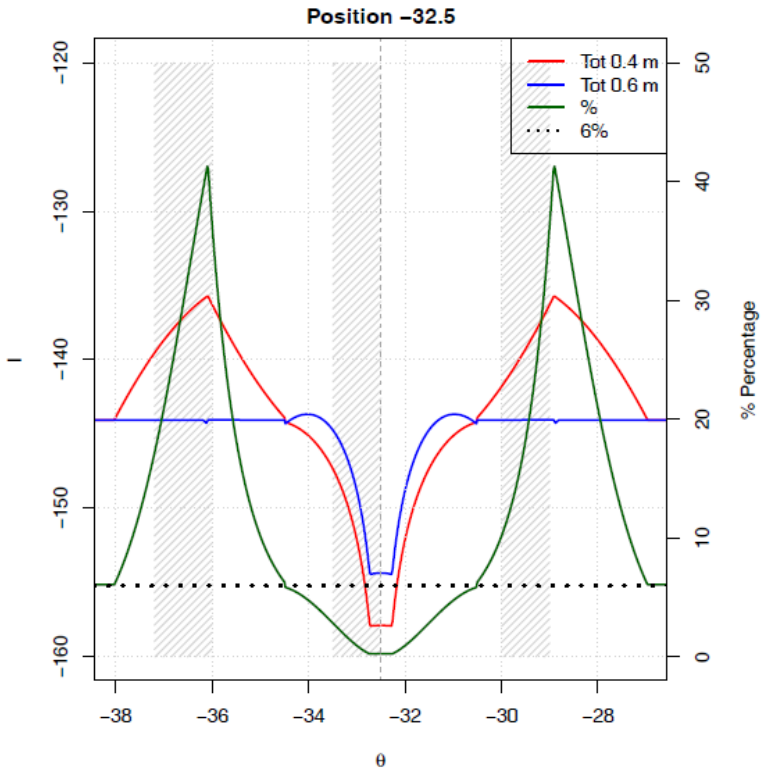


FIGURE A6-23B



As can be seen from the graphs, both the adjacent allowable arc portions for any orbital position of portion [33.5, 32.5]W entirely are in "non-securable" sections, i.e. network in compliance with Annex 1 pfd mask, which can be filed in the Western and Eastern adjacent allowable portions may create to the station, using antennas of 40 cm size, interference exceeding the allowable value ($\Delta T/T$ = 6%), the maximum value $\Delta T/T$ = ~41%.

Thus, the currently in allowable orbital portion [33.5, 32.5]W protection of the network with small antenna at the level of 6% is not guaranteed, possible maximum value of $\Delta T/T$ is ~41%, thus, the elimination/review of the Annex 7 limitations in this part of the arc will not lead to increase of allowable Annex 1 interference value.

1.4.5.3 Consideration for allowable portion of GSO orbital arc [30, 29]W

For western adjacent allowable portion of the orbital arc

TABLE A6-5A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[30, 29]W	30ºW	[35.5, 32]W	[33.5, 32.5]W	[33.5, 32.5]W⊂[35.5, 32]W	∩=100%
	29ºW	[34.5, 31]W		[33.5, 32.5]W⊂[35.5, 32]W	∩=100%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-5B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Existence of intersection of non-securable section with adjacent allowable portion	
[30, 29]W	30ºW	[28, 24.5]W	[26, 24]W	[26, 24]W∩[28, 24.5]W	∩=75%
	29ºW	[27, 23.5]W		[26, 24]W⊂[27, 23.5]W	∩=100%

As can be seen from the tables, the Western adjacent [30, 29]W allowed arc portion as a whole falls into the non-securable sections of the GSO arc (corresponding to section B-C in Fig. A6-19), i.e. in this case, the protection by Annex 1 assignments with an antenna diameter of 40 cm at 6% is not provided from networks filed all over the neighbouring West allowable portion and in compliance with Annex 1 pfd mask, i.e. placed in the adjacent allowable portion space station will cause interference which exceeds which exceeds the allowable criterion ($\Delta T/T$ = 6%), and which the station with small antenna in allowable portion [30, 29]W is obliged to accept, as is in accordance with Annex 1 it is deemed unaffected.

For the Eastern adjacent [30, 29]W allowable portion the intersection with the non-securable portion varies is from 100% to 75%, i.e. in the from 25% to 0% of this portion the interference will not exceed permissible one, but in this case [30, 29]W if there are some positions with protection from the “eastern” station, there is no protection from “western” positions.

Dependence (Figs A6-24A and A6-24B) of “allowed” by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion[30, 29]W. With shading are shown allowable for filing networks portions, to better

illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-24A

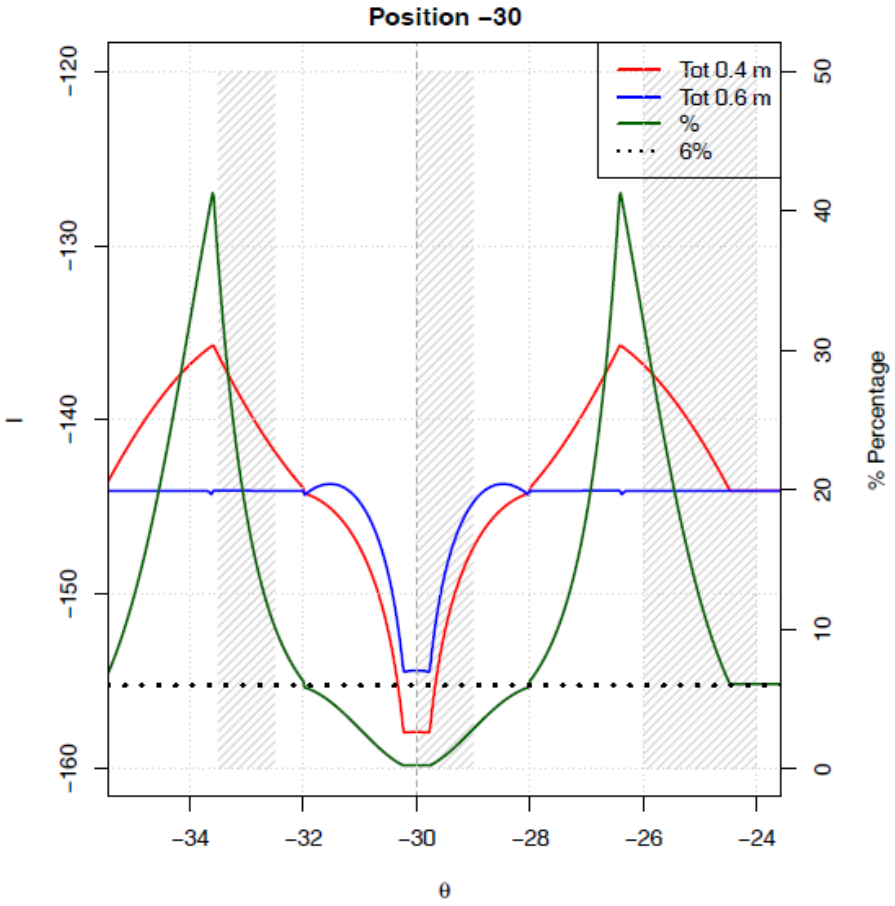
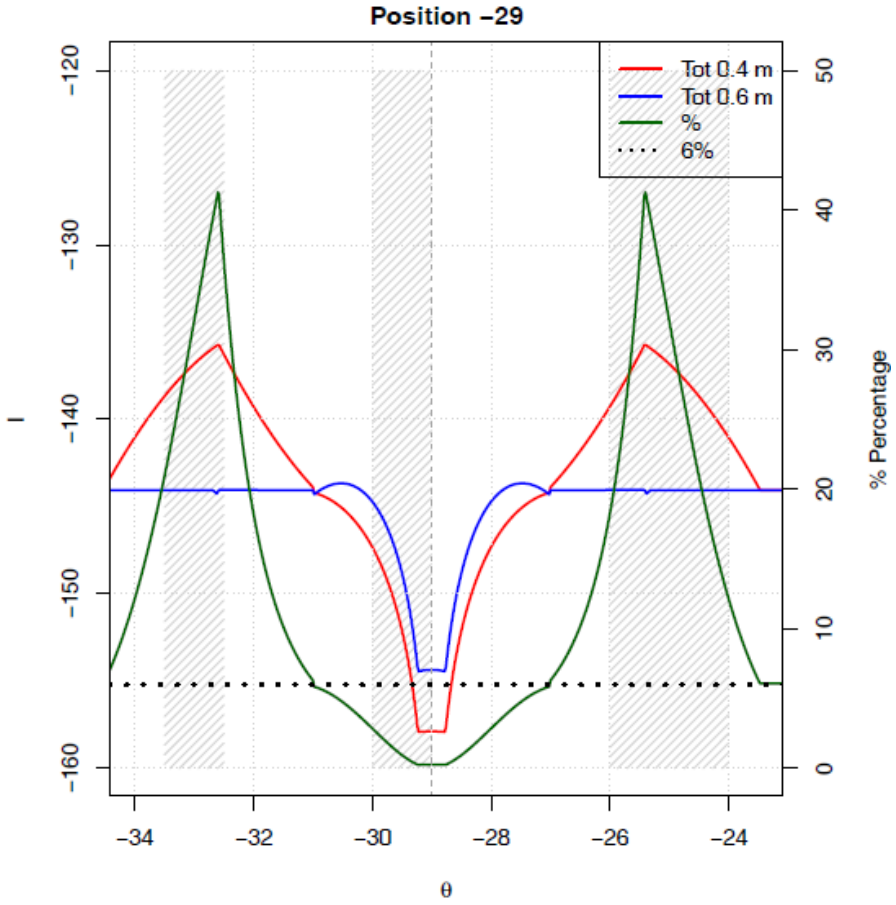


FIGURE A6-24B



Figures show that Western allowable arc portion as a whole falls into the "non-securable section" for all points of the considered arc portion [30, 29]W, and for a number of positions of considered portion interference from networks in the Eastern section will be maximal, the maximum value $\Delta T/T$ = ~41%, i.e., when placing a new network in any part of the Eastern arc portion is allowed to cause interference to stations with small antenna (40 cm), which exceeds the permissible value $\Delta T/T$ = 6%.

For Eastern the intersection with the non-securable section is from 75% to 100%, however, in this case, one cannot speak about a guaranteed 6% protection in this case, because the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed with non-securable sections from both sides, and in this case such protection "from the East" is only guaranteed in the best case (position 30 W) from quarter points of the portion [26, 24]W.

1.4.5.4 Consideration for allowable portion of GSO orbital arc [26, 24]W

For western adjacent allowable portion of the orbital arc

TABLE A6-6A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Existence of intersection of non-securable section with adjacent allowable portion	
[26, 24]W	26ºW	[31.5, 28]W	[30, 29]W	[30, 29]W⊂[31.5, 28]W	∩=100%
	24ºW	[29.5, 26]W		[30, 29]W∩[38, 34.5]W	∩=50%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-6B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[26, 24]W	26ºW	[24, 20.5]W	[20, 18]W	[20, 18]W⊄[24, 20.5]W	∩=0%
	24ºW	[22, 18.5]W		[20, 18]W∩[22, 18.5]W	∩=75%

As can be seen from the Tables, for the Western adjacent to [26, 24]W allowable portion the intersection with the non-securable section varies from 100% to 50%. For the Eastern adjacent to [26, 24]W allowable portion the intersection with the non-securable section varies from 0% to 75%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T = 6\%$, which the network at the arc portion [26, 24]W is obliged to accept, as in accordance with Annex 1 it is considered as unaffected.

Dependence (Figs A6-25A and A6-25B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [26, 24]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-25A

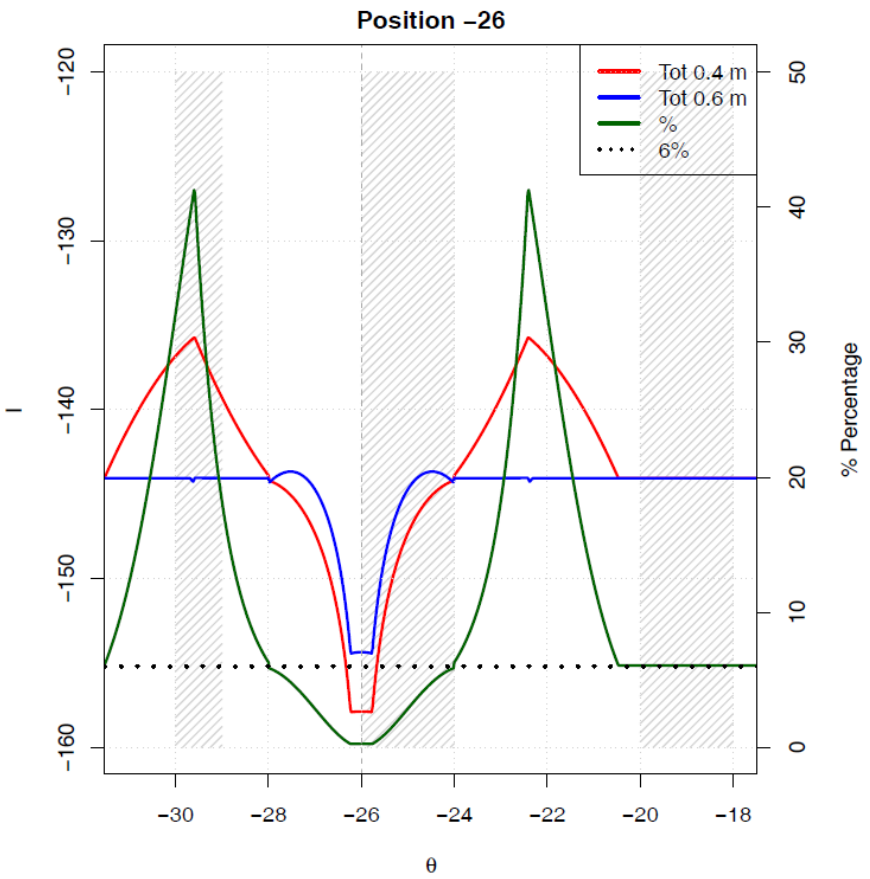
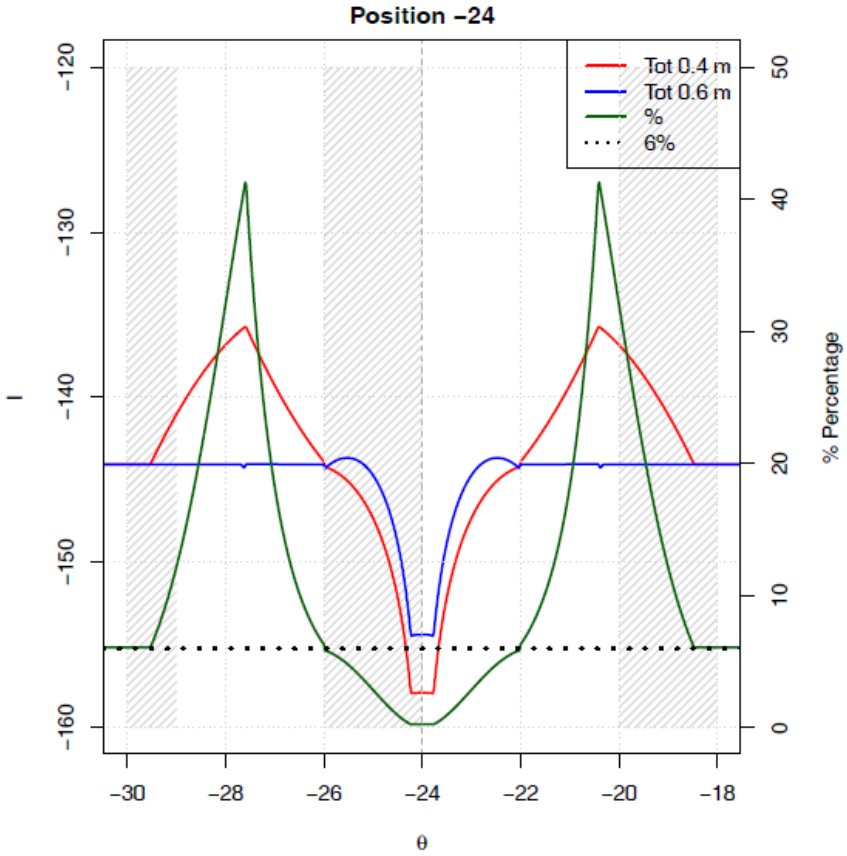


FIGURE A6-25B



As can be seen from the graphs for the Western portion intersection with the non-securable section varies from 100% to 50%, for the Eastern portion intersection with the non-securable section varies from 0% to 75%. However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~41% from networks in the Western allowable arc portion and $\Delta T/T$~32% from networks in the Eastern allowable arc portion.

1.4.5.5 Consideration for allowable portion of GSO orbital arc [20, 18]W

For western adjacent allowable portion of the orbital arc

TABLE A6-7A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[20, 18]W	20ºW	[25.5, 22]W	[26, 24]W	[26, 24]W∩ [25.5, 22]W	∩=75%
	18ºW	[23.5, 20]W		[26, 24]W⊄[23.5, 20]W	∩=0%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-7B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[20, 18]W	20ºW	[18, 14.5]W	[14, 12]W	[14, 12]W⊄[18, 14.5]W	∩=0%
	18ºW	[16, 12.5]W		[14, 12]W∩[16, 12.5]W	∩=75%

As can be seen from the Tables, for the Western adjacent to [20, 18]W allowable portion the intersection with the non-securable section varies from 75% to 0%. For the Eastern adjacent to [20, 18]W allowable portion the intersection with the non-securable section varies from 0% to 75%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T = 6\%$, which the network at the arc portion [20, 18]W is obliged to accept, as in accordance with Annex 1 it is considered as unaffected.

Dependence (Figs A6-26A and A6-26B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [20, 18]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-26A

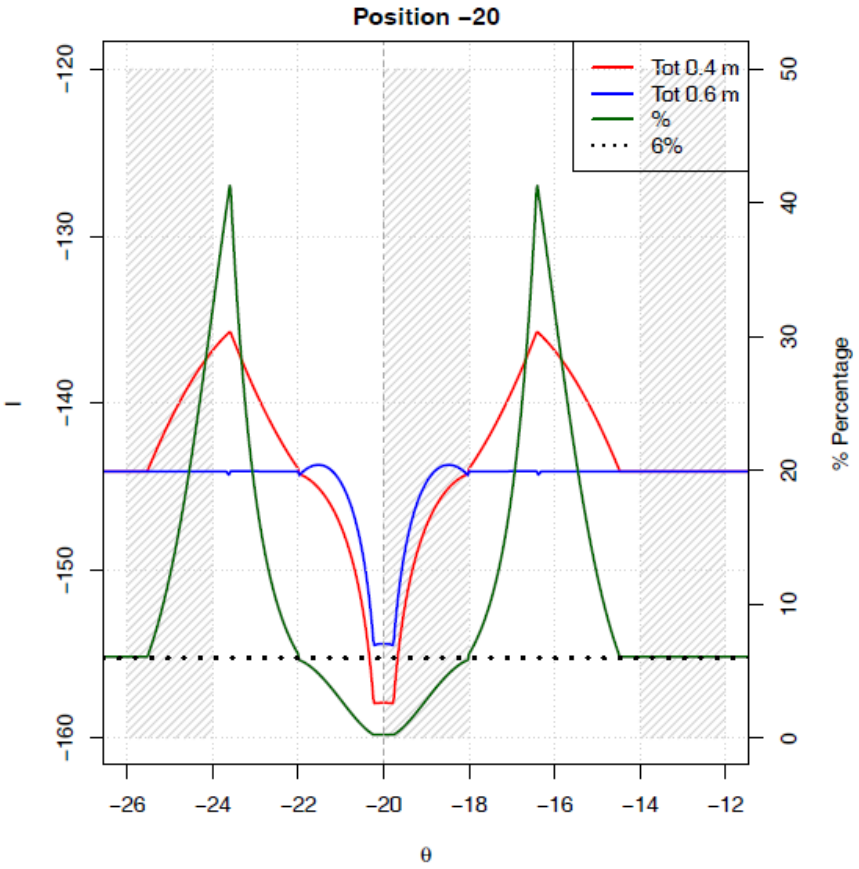
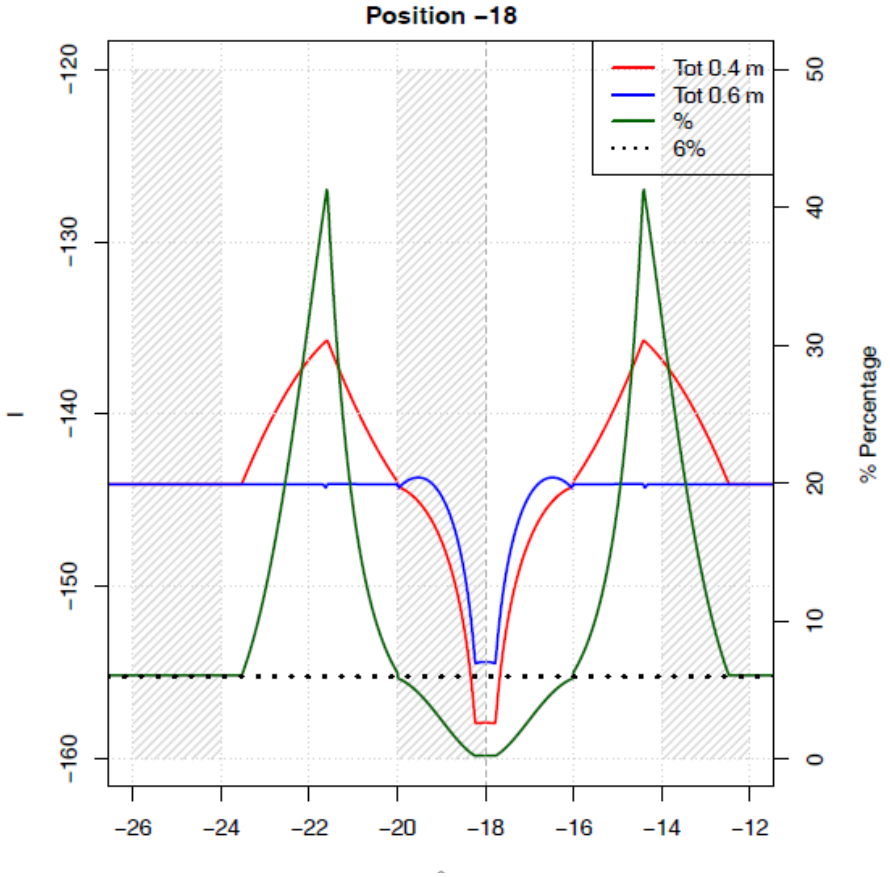


FIGURE A6-26B



As can be seen from the graphs for the Western portion intersection with the non-securable section varies from 75% to 0%, for the Eastern portion intersection with the non-securable section varies from 0% to 75%/ However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~35% from networks in the Western allowable arc portion and $\Delta T/T$~32% from networks in the Eastern allowable arc portion.

1.4.5.6 Consideration for allowable portion of GSO orbital arc [14, 12]W

For western adjacent allowable portion of the orbital arc.

TABLE A6-8A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[14, 12]W	14ºW	[19.5, 16]W	[20, 18]W	[20, 18]W∩ [19.5, 16]W	∩=75%
	12ºW	[17.5, 14]W		[20, 18]W⊄[17.5, 14]W	∩=0%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-8B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[14, 12]W	14ºW	[12, 8.5]W	[8, 6]W	[8, 6]W⊄[12, 8.5]W	∩=0%
	12ºW	[10, 6.5]W		[8, 6]W∩[10, 6.5]W	∩=75%

As can be seen from the Tables, for the Western adjacent to [14, 12]W allowable portion the intersection with the non-securable section varies from 75% to 0%. For the Eastern adjacent to [14, 12]W allowable portion the intersection with the non-securable section varies from 0% to 75%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T = 6\%$, which the network at the arc portion [14, 12]W is obliged to accept, as in accordance with Annex 1 it is considered as unaffected.

Dependence (Figs A6-27A and A6-27B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [14, 12]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

Since the zone of maximum interference in this case falls on the not allowable arc portion, the elimination of limitations in the intervals [12, 8]W and [12, 8]W can worsen the situation for the networks in allowable arc portion [14, 12]W. However, there is no simultaneous protection of small antenna at 6% level by Annex 1 from both sides.

FIGURE A6-27A

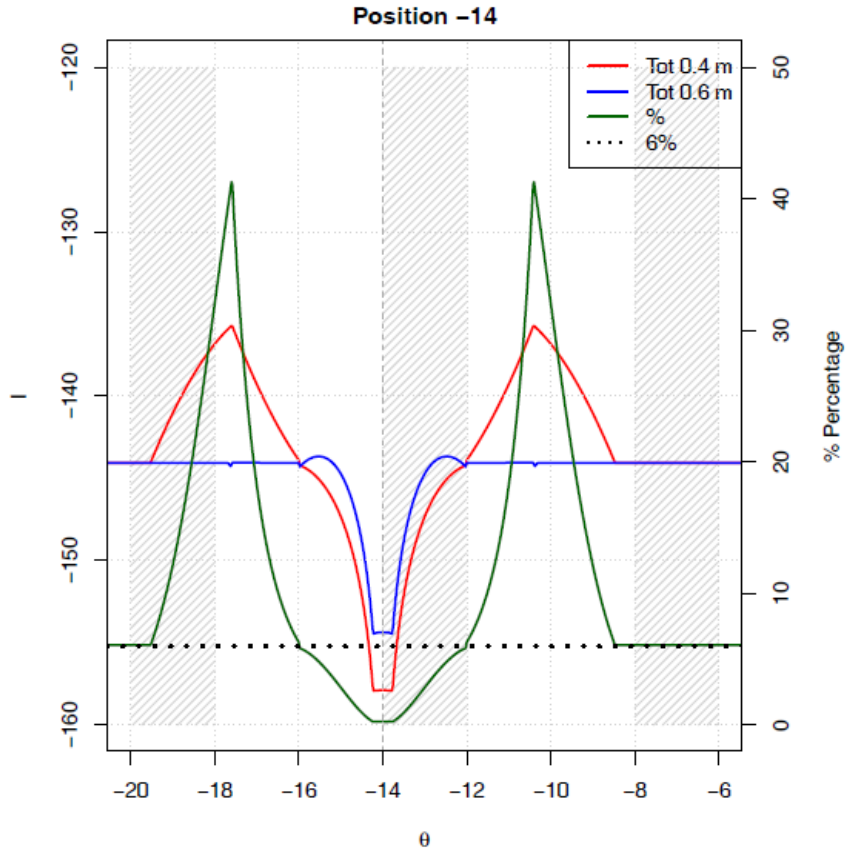
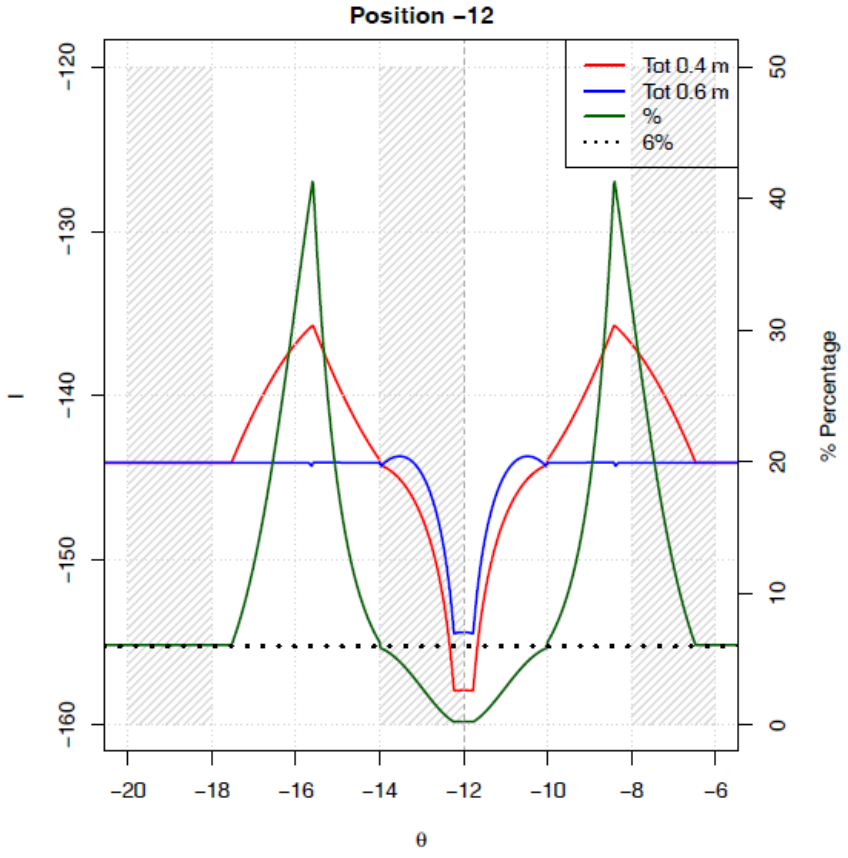


FIGURE A6-27B



As can be seen from the graphs for the Western portion intersection with the non-securable section varies from 75% to 0%, for the Eastern portion intersection with the non-securable section varies from 0% to 75%/ However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~32% from networks in the Western allowable arc portion and $\Delta T/T$~32% from networks in the Eastern allowable arc portion.

1.4.5.7 Consideration for allowable portion of GSO orbital arc [8, 6]W

For western adjacent allowable portion of the orbital arc

TABLE A6-9A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[8, 6]W	8ºW	[13.5, 10]W	[14, 12]W	[14, 12]W∩[13.5, 10]W	∩=75%
	6ºW	[8, 11.5]W		[14, 12]W⊄[8, 11.5]W	∩=0%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-9B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[8, 6]W	8ºW	[6, 2.5]W	[4]W	[4]W⊂[6, 2.5]W	∩=100%
	6ºW	[4, 0.5]W		[4]W⊂[4, 0.5]W	∩=100%

As can be seen from the Tables, for the Western adjacent to [8, 6]W allowable portion the intersection with the non-securable section varies from 75% to 0%. For the Eastern adjacent to [20, 18]W allowable portion the intersection with the non-securable section is 100%/ However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T$ = 6%, which the network at the arc portion [20, 18]W is obliged to accept, as in accordance with the Annex 1 it is considered as unaffected.

Dependence (Figs A6-28A and A6-28B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [8, 6]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-28A

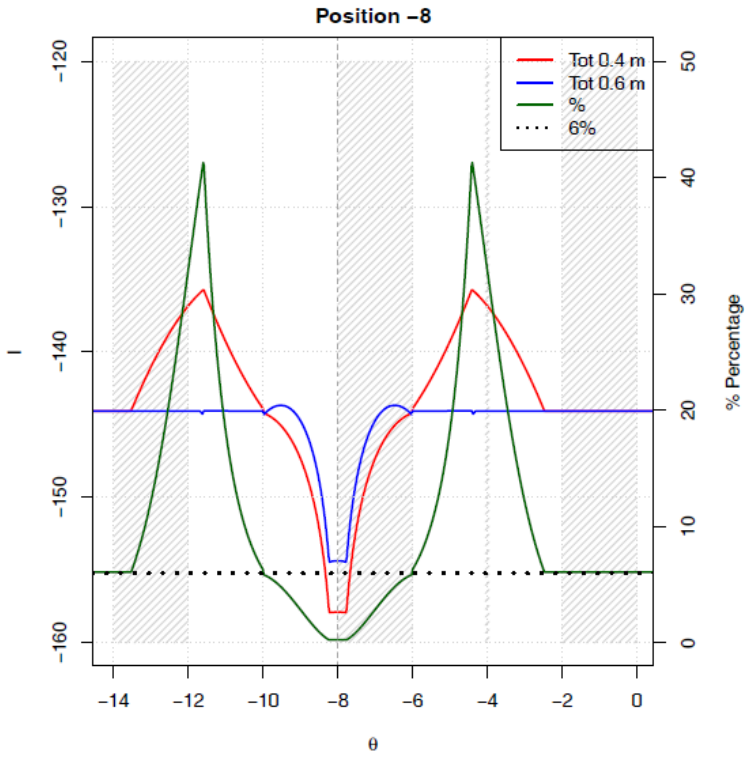
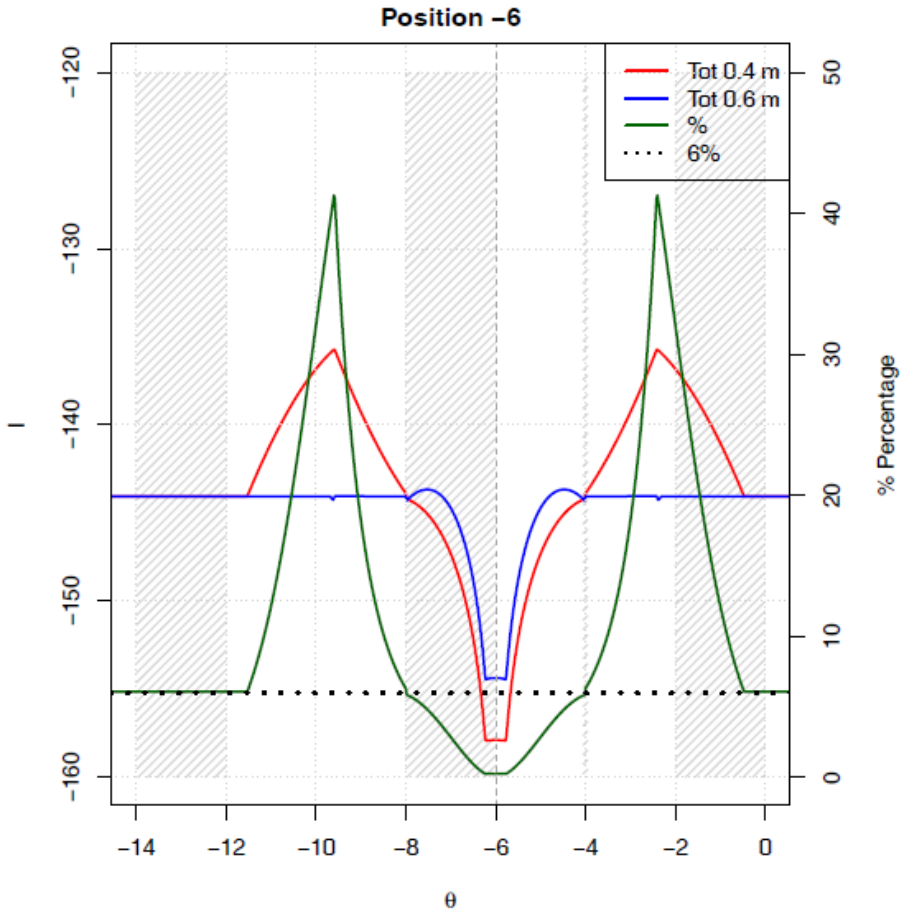


FIGURE A6-28B



As can be seen from the graphs for the Western portion intersection with the non-securable section varies from 75% to 0%, for the Eastern portion intersection with the non-securable section is 100%. However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~32% from networks in the Western allowable arc portion and $\Delta T/T$~32% from networks in the Eastern allowable arc portion, in addition from the next [2 0]W allowable arc portion is possible interference od up to $\Delta T/T$=~29%.

1.4.5.8 Consideration for allowable portion of GSO orbital arc [4]W

For western adjacent allowable portion of the orbital arc

TABLE A6-10A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[4]W	4ºW	[6, 9.5]W	[8, 6]W	[8, 6]W⊂[6, 9.5]W	∩=100%

For eastern adjacent allowable portion of the orbital arc

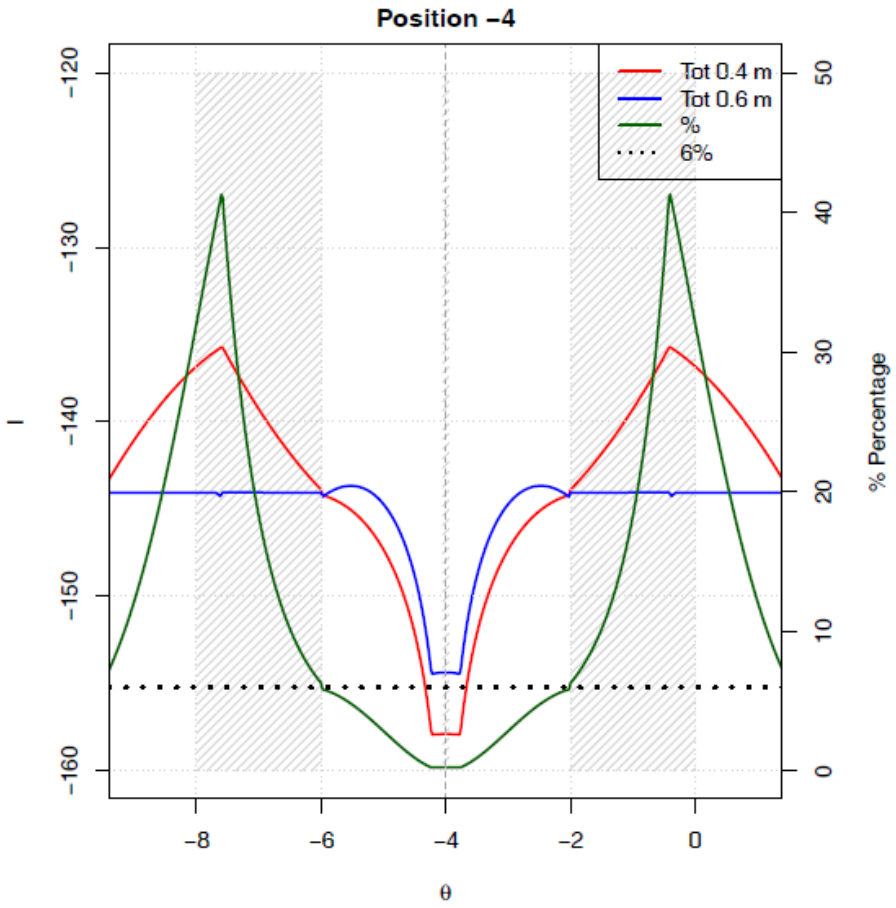
TABLE A6-10B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[4]W	4ºW	[2, -1.5]W	[2, 0]W	[2, 0]W⊂[2, -1.5]W	∩=100%

As can be seen from the Tables both adjacent to the [4]W allowed arc portions as a whole fall into the non-securable sections of the GSO arc (corresponding to sections C−B, B−C in Fig. 1), i.e. in this case, the protection of assignments with an antenna diameter of 40 cm at 6% from networks in compliance with Annex 1 is not provided. Filed in both allowable adjacent portions networks will create interference that exceeds the permissible value of $\Delta T/T$ = 6%, and which the network in arc portion [4]W is obliged to accept because in accordance with the Annex 1 criterion it is deemed unaffected. Possible the maximum value from both Western and Eastern portions is $\Delta T/T$ = ~41%.

Dependence (Fig. A6-29) of “allowed” by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the allowed orbital arc portion [4]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-29



As can be seen from the graph for the Western portion intersection with the non-securable section is 100%, for the Eastern portion intersection with the non-securable section is 100%. However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~41% from networks in the Western allowable arc portion and $\Delta T/T$~41% from networks in the Eastern

1.4.5.9 Consideration for allowable portion of GSO orbital arc [2, 0]W

For western adjacent allowable portion of the orbital arc.

TABLE A6-11A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[2, 0]W	2ºW	[7.5, 4]W	[4]W	[4]W⊂[7.5, 4]W*	∩=100%
	0ºW	[5.5, 2]W		[4]W⊂ [5.5, 2]W	∩=100%

* In the non-*securable* section partially (75%) falls the following [4]W allowable orbital arc portion [8, 6]W.

For eastern adjacent allowable portion of the orbital arc.

TABLE A6-11B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	Allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[2, 0]W	2ºW	[0, 3.5]E	[4, 6]E	[4, 6]E⊄[24, 20.5]W	∩=0%
	0ºW	[2, 5.5]E		[4, 6]E∩[22, 18.5]W	∩=75%

As can be seen from the Tables, for the Western adjacent to [2, 0]W allowable portion the intersection with the non-securable section is 100%. For the Eastern adjacent to [2, 0]W allowable portion the intersection with the non-securable section varies from 0% to 75%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T$ = 6%, which the network at the arc portion [2, 10]W is obliged to accept, as in accordance with Annex 1 it is considered as unaffected.

Dependence (Figs A6-30A and A6-30B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [2, 0]W. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-30A

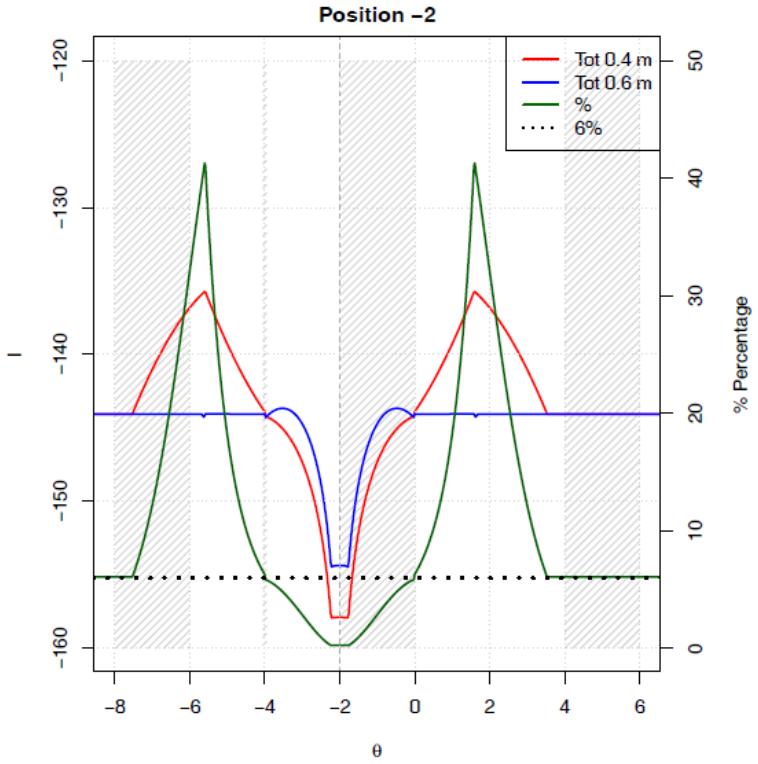
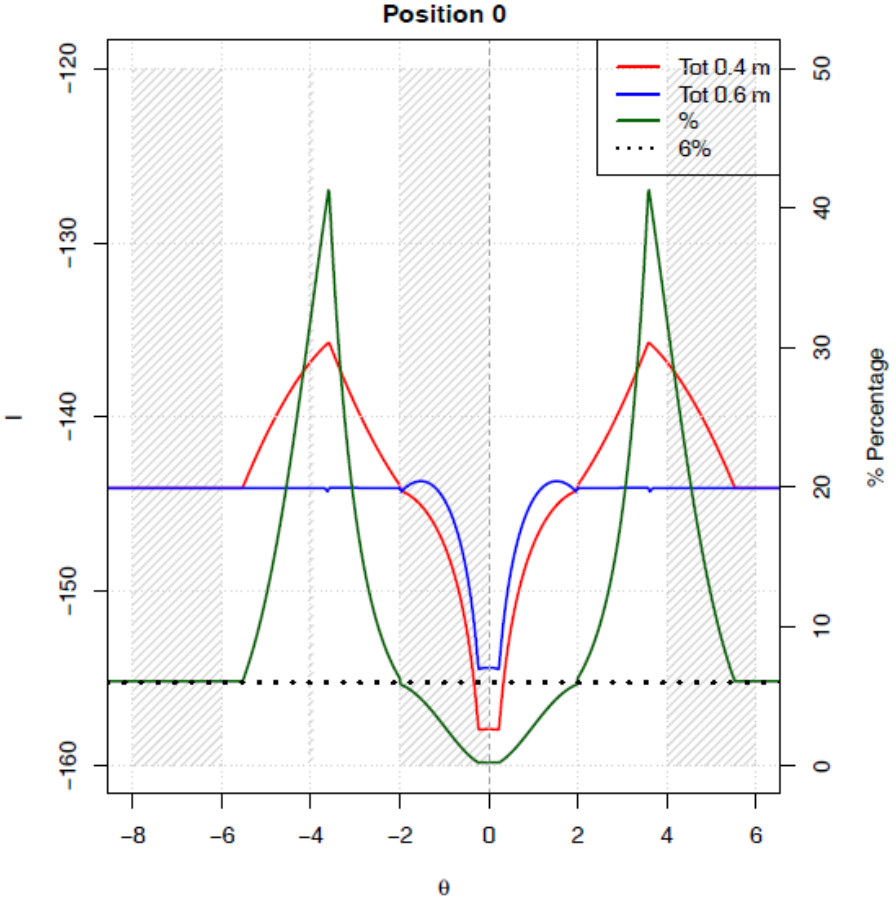


FIGURE A6-30B



As can be seen from the graphs for the Western portion intersection with the non-securable section is 100%, for the Eastern portion intersection with the non-securable section varies from 0% to 75%. However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~32% from networks in the Western allowable arc portion and $\Delta T/T$~32% from networks in the Eastern allowable arc portion.

1.4.5.10 Consideration for allowable portion of GSO orbital arc [4, 6]E

For western adjacent allowable portion of the orbital arc

TABLE A6-12A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[4, 6]E	4ºE	[2E, 1.5W]	[2, 0]W	[2, 0]W∩[2E, 1.5W]	∩=75%
	6ºE	[4, 0.5]E		[2, 0]W⊄[4E, 0.5]E	∩=0%

For eastern adjacent allowable portion of the orbital arc

TABLE A6-12B

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	allowable adjacent arc portion	Intersection of non-securable section with adjacent allowable portion	
[4, 6]E	4ºE	[6, 9.5]E	[9]E	[9]E⊂[6, 9.5]E	∩=100%
	6ºE	[8, 11.5]E		[9]E⊂ [8, 11.5]E	∩=100%

As can be seen from the Tables, for the Western adjacent to [4, 6]E allowable portion the intersection with the non-securable section varies from 75% to 0%. For the Eastern adjacent to [4, 6]E allowable portion the intersection with the non-securable section is 100%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T = 6\%$, which the network at the arc portion [4, 6]E is obliged to accept, as in accordance with Annex 1 it is considered as unaffected.

Dependence (Figs A6-31A and A6-31B) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the start and end points of the allowed orbital arc portion [4, 6]E. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-31A

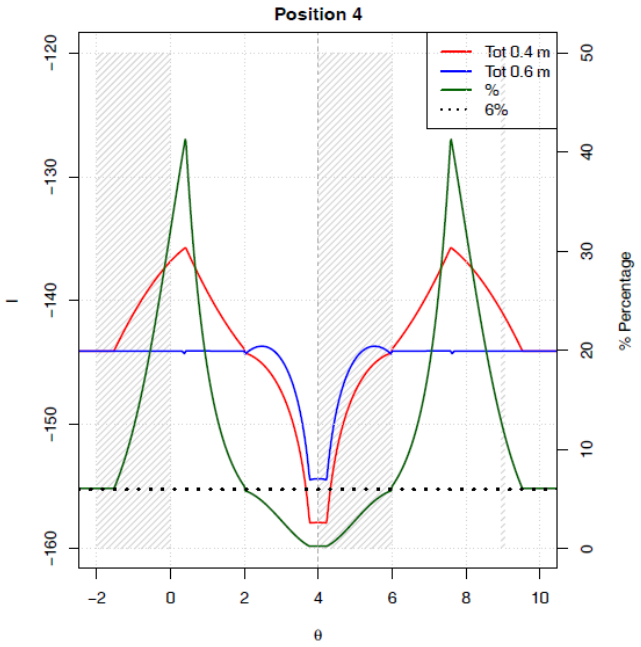
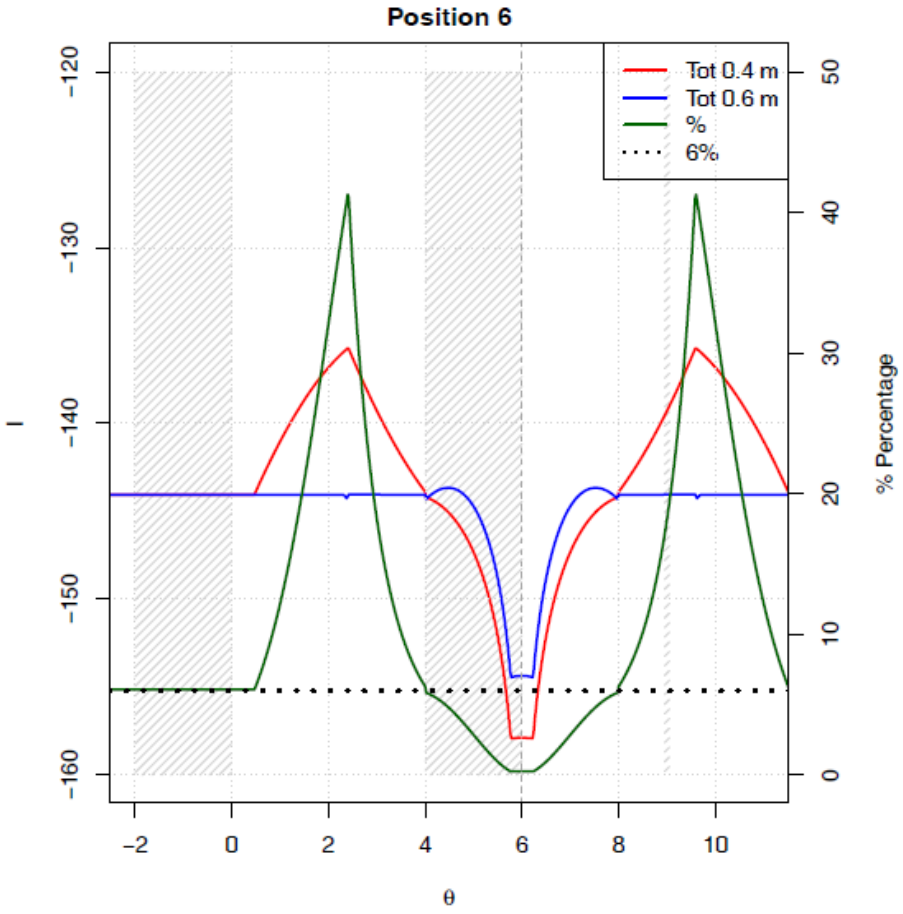


FIGURE A6-31B



As can be seen from the graphs for the Western portion intersection with the non-securable section varies from 75% to 0%, for the Eastern portion intersection with the non-securable section is 100%. However, in this case, one cannot speak about a guaranteed 6% protection in this case, because since the protection by Annex 1 at the level $\Delta T/T$ = 6% from networks that can be filed in the allowed arc portions is ensured only in the case of no intersection of allowed portion with non-securable sections from both sides. The maximum possible value $\Delta T/T$~32% from networks in the Western allowable arc portion and $\Delta T/T$~18% from networks in the Eastern allowable arc portion.

1.4.5.11 Consideration for allowable portion of GSO orbital arc [9]E

For western adjacent allowable portion of the orbital arc.

TABLE A6.13A

Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	allowable adjacent arc portion	Existence of intersection of non-securable section with adjacent allowable portion	
[9]E	9ºE	[3.5, 7]E	[4, 6]E	[4, 6]E⊂[3.5, 7]E	∩=100%

For eastern adjacent allowable portion of the orbital arc.

TABLE A6-13B

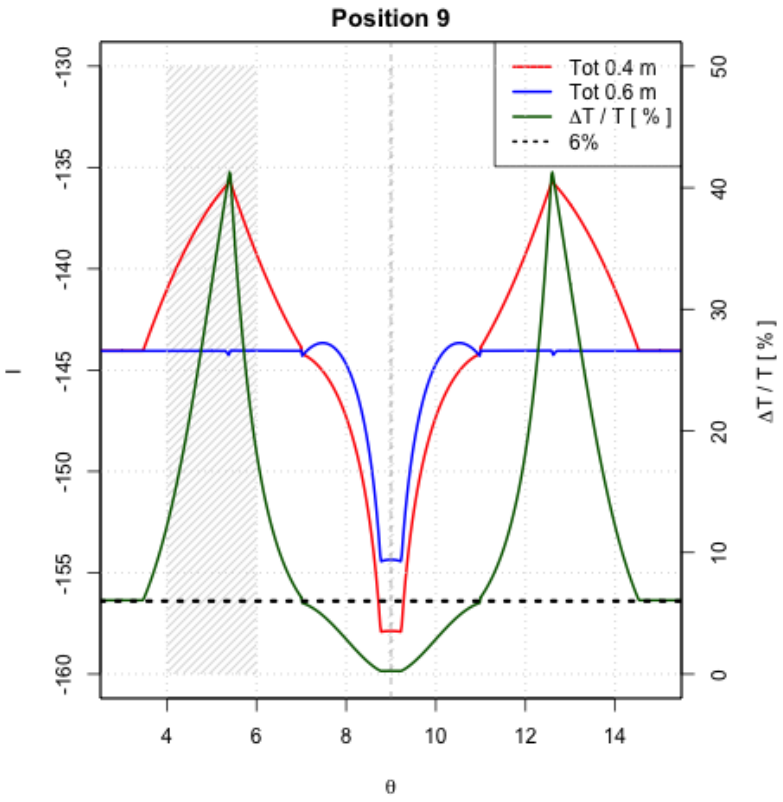
Orbital arc under consideration	Start & end points of the portion under consideration	Non-securable orbital sections (for 40 cm antenna)	allowable adjacent arc portion	Existence of intersection of non-securable section with adjacent allowable portion	
[9]E	9ºE	[11, 14.5]E	[10, 18]E*	[10, 18]E⊂[11, 14.5]E	∩=100%

* Starting from position 10ºE there are no orbital position limitations, the position 18ºE is labeled as positior at the orbital separation of 9º from [9]E.

As can be seen from the Tables, for the Western and Eastern adjacent to [9]E allowable portion the intersection with the non-securable section is 100%. However, for allowable adjacent (West and East) portions of the arc can be filed networks that will cause interference that exceeds the allowable value of $\Delta T/T$ = 6%, which the network at the arc portion [9]E is obliged to accept, as in accordance with the Annex 1 it is considered as unaffected.

Dependence (Fig. A6-32) of "allowed" by Annex 1 interference level, caused to earth station with 40 cm antenna of 40 cm size is presented for the allowed orbital arc portion [9]E. With shading are shown allowable for filing networks portions, to better illustrate the levels of interference that currently, with the existing provisions of Annex 7 network with 40 cm antenna is obliged to accept.

FIGURE A6-32



As can be seen from Fig. A6-32 for portion [9]E, the Western allowed portion of orbital arc as a whole falls within the "non-securable" zone, in this case the value $\Delta T/T$ can reach a maximum value ~41%. Since starting from position 10ºE there are no orbital limitations, and "non-securable" for

antenna of 40 cm size zone begins from ~11°E, network in GSO positions starting from this GSO position and being in compliance with Annex 1 pfd mask could cause station using antenna of 40 cm size interference, $\Delta T/T$ up to ~41%.

1.4.5.12 Results of analysis

Table A6-14 summarizes the results of the analysis produced in Tables above and in appropriate Figures showing change versus orbital separation of "allowed" by Annex 1 level of interference, which shall be accepted by station using antenna of 40 cm size. For all the allowed portions of orbital arc (Table 1 of Annex 7) Table A6-14 provides information on existence and degree of intersection of non-securable zone with adjacent allowable orbital arc portions, where could be filled frequency assignments although in compliance with Annex 1 pfd mask, and however, creating interference exceeding permissible value. In Table A6-14 for all allowable arc portions is included information on maximum $\Delta T/T$ values, from networks in adjacent portions.

TABLE A6-14

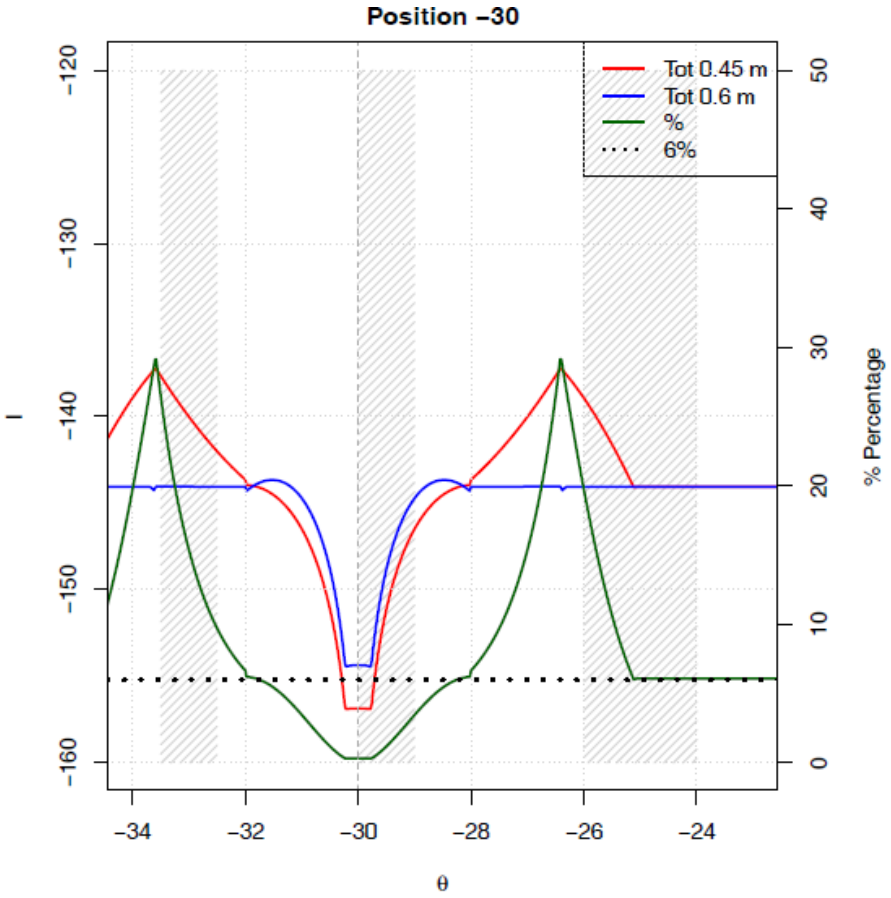
№	Allowable portion of orbital arc under consideration	Estimation of the existence and degree of intersection of non-securable zone, corresponding to the segment B-C in Figure 1		The maximum possible $\Delta T/T$ value caused by networks which can be filed:	
		with Western allowable portion	with Eastern allowable portion	in the Western allowable portion	in the Eastern allowable portion
1	[37.2, 36]W	–	100%	–	41%
2	[33.5, 32.5]W	100%	100%	41%	41%
3	[30, 29]W	100%	75–100%	41%	41%
4	[26, 24]W	100–50%	0–75%	41%	32%
5	[20, 18]W	75–0%	0–75%	35%	32%
6	[14, 12]W	75–0%	0–75%	32%	32%
7	[8, 6]W	75–0%	100%	32%	41%
8	[4]W	100%	100%	41%	41%
9	[2, 0]W	100%	100%	41%	32%
10	[4, 6]E	75–0%	100%	32%	41%
11	[9]E	100%	–	41%	41%

The Table shows that there is no allowable portion of orbital arc (Table 1 of Annex 7 to RR Appendix **30**), where stations with small antenna (40 cm) could obtain protection defined by Annex 1 pfd mask both from space stations in the Western and Eastern allowable adjacent portions.

1.4.6 Protection level of assignments in concrete orbital positions

Since the BR has already received filings for frequency assignments with small antennas for GSO positions within the allowable portions of orbital arc, is of interest to analyse the existing levels of protection of such assignments. Figures A6-33 to A6-35 show the levels of the interfering signal and the obtained $\Delta T/T$ values for three specific GSO positions (30 W, 33.5W and 4.8E), where there are filings with small antennas: of 45 cm and 40 cm sizes, respectively.

FIGURE A6-33



The Figure shows that when filed in the allowable adjacent portions of the GSO arc networks which meet the Annex 1 pfd mask, the network in the position of 30 W using the antenna 45 cm, will be forced to accept interference which exceeds the allowable criterion ($\Delta T/T$ = 6%):

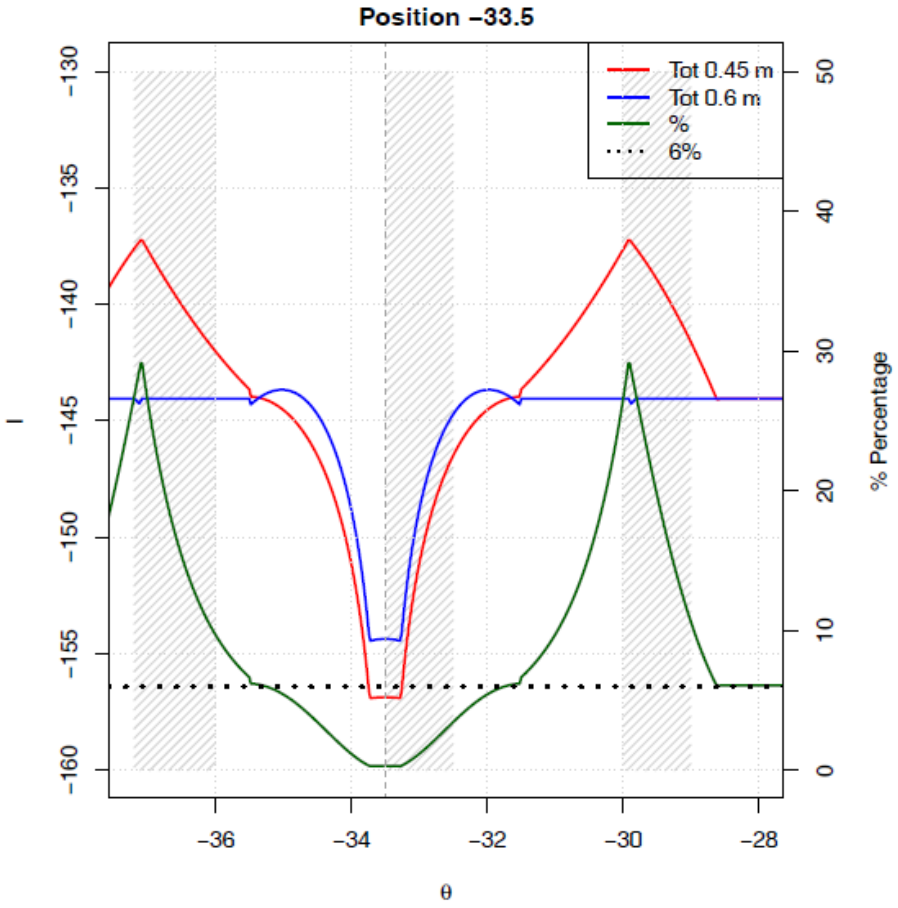
– from networks placed in allowable portion [33.5÷32.5]W$\Delta T/T$ up to ~26.5%,

– from networks placed in allowable portion [26÷24]W$\Delta T/T$ up to~19.7%.

Thus, the network in 30 W position using antenna of 45 cm size, currently has no protection at the level of 6% by Annex 1 pfd mask from possible networks in compliance with Annex 1 pfd mask and filed in allowable portions of the orbital arc to the East and to the West from the position concerned.

Thus, orbital position limitations (Table 1, Annex 7) do not contribute to the protection network using antenna of 45 cm size in the position 30 W at permissible interference level($\Delta T/T$ = 6%).

FIGURE A6-34



The Figure shows that when filed in the allowable adjacent portions of the GSO arc networks which meet the Annex 1 pfd mask, the network in the position of 33.5 W using the antenna 45 cm, will be forced to accept interference which exceeds the allowable criterion ($\Delta T/T$ = 6%):

– from networks placed in allowable portion [36÷37.2]W$\Delta T/T$ up to ~29.1%,

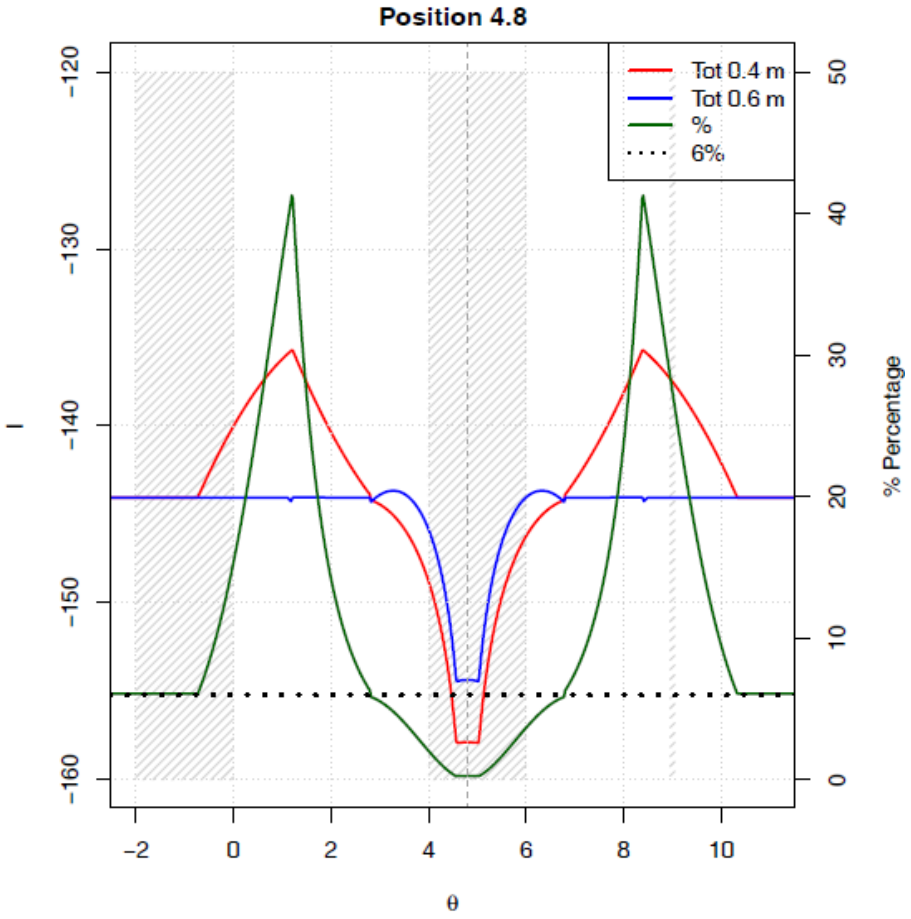
– from networks placed in allowable portion [30÷29]WΔT/T up to ~29.1%.

It should be noted that the network in position 30 W if it meets the Annex 1 pfd mask may cause network in positions 33.5 W interference exceeding permissible criterion, $\Delta T/T$ = ~26.5%

Thus, the network in 30 W position using antenna of 45 cm size, currently has no protection at the level of 6% by Annex 1 pfd mask from possible networks in compliance with Annex 1 pfd mask and filed in allowable portions of the orbital arc to the East and to the West from the position concerned.

Thus, orbital position limitations (Table 1, Annex 7) do not contribute to the protection network using antenna of 45 cm size in the position 33.5 W at permissible interference level($\Delta T/T$ = 6%).

FIGURE A6-35



The Figure shows, that when filed in the allowable adjacent portions of the GSO arc networks which meet the Annex 1 pfd mask, the network in the position of 4.8 E using the antenna 40 cm, will be forced to accept interference which exceeds the allowable criterion ($\Delta T/T$ = 6%):

– from networks placed in allowable portion [0÷2]W $\Delta T/T$ up to~15.3%,

– from networks placed in allowable portion [9]E, $\Delta T/T$ up to~27.4%.

Thus, the network in 4.8ºE position using antenna of 40 cm size, currently has no protection at the level of 6% by Annex 1 pfd mask from possible networks in compliance with Annex 1 pfd mask and filed in allowable portions of the orbital arc to the East and to the West from the position concerned.

1.4.7 Supplement to Study #3: Estimation of the protection level of the earth station with antenna smaller than 60 cm provided by the presence of forbidden arc portions

1.4.7.1 Introduction

As Resolution **557(WRC-15)** in *noting c)* and *recognizing b)* prescribes that existing FSS networks operating in the frequency bands mentioned in *considering b)* and BSS networks implemented[4] in accordance with the current provisions of Annex 7 to Appendix **30** shall continue to be protected, it is reasonable to assess the role of not allowed (forbidden) orbital arc portions in protection of earth stations with antenna sizes smaller than 60 cm, whether they could guarantee protection of such stations by some of not allowed arc portions.

[4] See §4.3 of this Report.

1.4.7.2 Estimation of the protection level provided to the networks with “small” antennas by the presence of forbidden arc portions

Used methodology

The technique used to determine the level of interference caused the network with “small” antenna by the network that satisfies the Annex 1 pfd mask, is described above.

Since the minimum antenna diameter which protection is guaranteed by the Annex 1 pfd mask is 60 cm, it is obvious that at orbital separations where the selectivity of the “small” antenna is lower in comparison to 60 cm antenna, protection of the earth station with such antenna with 6% of the allowable relative noise increase will not be provided. So for antenna of 40 cm of size the orbital separation, at which the level of allowed interference from the network in compliance with Annex 1 pfd mask will be exceeded, is from ~2° to 5.5°; for an antenna of 45 cm size − from ~2° to 5°. Thus, if the specified spacing intersects partially or completely with the forbidden portion of the orbital arc, the presence of this forbidden portion (or part of it) partially or completely protects the network with a small antenna. In other words, if the specified orbital separation intersects partially or wholly with the forbidden portion of the orbital arc, then the presence of this forbidden arc portion (or part of it) partially or completely protects the network with a “small” antenna.

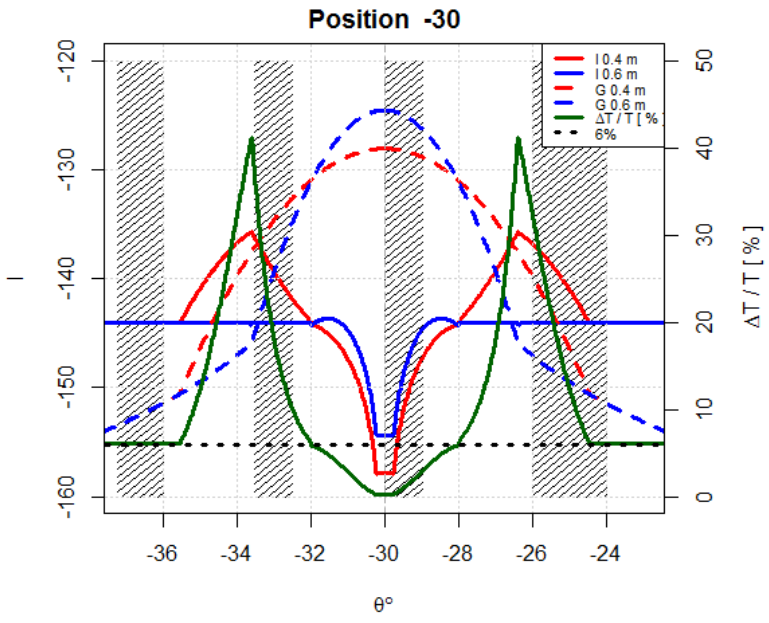
It should be noted that all the graphic material presented in Study #3 can be used for illustrations when necessary.

What is meant by the protection level provided by the forbidden orbital arc portion

Using as the example the dependence from the orbital separation of the "allowed” by Annex 1 level of interference (and $\Delta T/T$) for the earth station with antenna of 40 cm and 45 cm sizes (Figs A6-36 and A6-37) for the orbital position 30ºW, illustrates what is meant by providing protection of the network with a "small" antenna by forbidden arc portion or by its part (shaded areas show allowable for filing networks orbital arc portions).

The interference levels, prevented by the presence of the forbidden arc portions, were estimated according to the above methodology and were determined for three points of each allowed arc portion: the two endpoints and the centre.

FIGURE A6-36

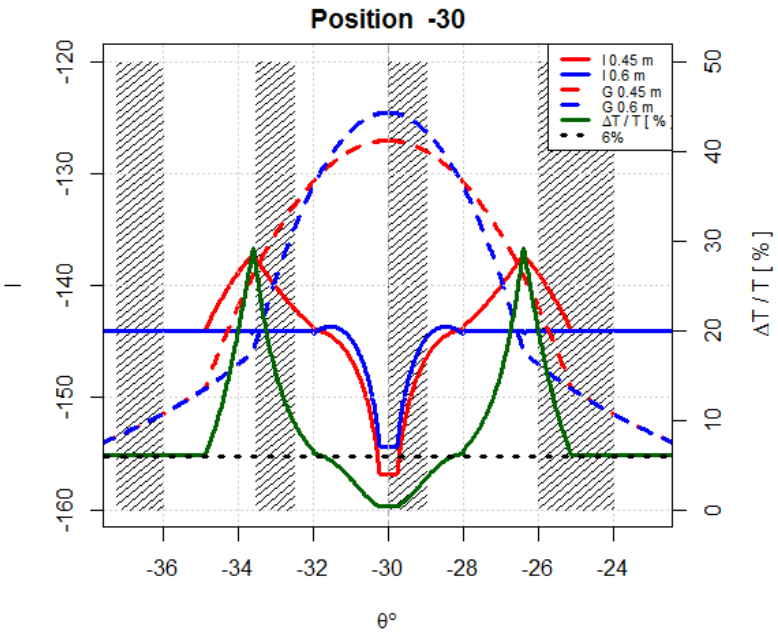


When considering the level of interference allowed by Annex 1 pfd mask that can be caused to the earth station with antenna of 40 cm size by the networks placed in the forbidden arc portion (in case of its cancellation), the presence of orbital separation within the forbidden arc portion where the ΔT/T criterion is not violated, can be determined as illustrated by the following example:

– in case of forbidden arc portion [29ºW-26ºW] it is seen that the protection of network with an antenna of 40 cm of size, when the network is placed at 30ºW orbital position, by this forbidden arc portion is provided only in the arc range [~28ºW-26ºW], i.e. from the point of view of providing protection of "small" antennas, this forbidden portion can be reduced by 1 degree;

– similarly, the forbidden arc portion [32.5ºW-30ºW] can be reduced by 2 degrees, as it provides protection of the station with "small" antenna (40 cm) only in the arc range [~32.5ºW-32ºW].

FIGURE A6-37



Similarly, for the case of antenna 45 cm size:

In this case, a similar reduction of the forbidden arc portions is possible from the point of view of providing protection to the station with antenna of 45 cm size, since only segments of adjacent forbidden arcs provide protection − sections [~ 28W-26W] and [~ 32.5W-32W].

Thus, from the point of view of preserving the protection of station with "small" antennas which is provided by intersection of the forbidden arc portion (or its part) with the area of lower selectivity of the "small" antenna, the forbidden arc portions can be reduced by the segment t in which $\Delta T/T \leq 6\%$.

In the same way all the allowable arc portions are analysed in relation to protection of the stations with "small" antennas (40 cm) from the networks in compliance with Annex 1 pfd mask in adjacent forbidden arc portions. In this case the size of the forbidden arc portion which provides protection to the station with "small" antenna is estimated, as well as the maximum allowed by pfd mask interference level when placing the network in the forbidden arc portion is calculated.

In addition, in order to compare the results of Studies #2 and #3, we included estimation and comparison of the levels of aggregate interference from the two networks in adjacent allowable and adjacent forbidden arc portions.

In cases when the next forbidden arc portion after the nearest forbidden portion provides more protection, then information for this adjacent forbidden portion is also provided.

1.4.7.3 Protection provided by forbidden orbital arc portions

The level of interference from networks in adjacent western and eastern forbidden arc portions is evaluated and, for comparison, from networks in adjacent allowable arc portions. However, in some cases, when the interference level allowed by Annex 1 caused by network in the next forbidden portion is higher than in the adjacent forbidden portion, the next forbidden portion was also taken into account. This is illustrated in Fig. A6-36: the interference level, from which the next forbidden portion ([36W-33.5W]) protects "small" antenna is higher than that guaranteed by adjacent forbidden portion.

1.4.7.3.1 Analysis of forbidden portion (36ºW, 33.5ºW), adjacent to allowable arc portion [37.2, 36]W

For western adjacent forbidden portion of the orbital arc

Since starting from position 37.2W to the West, there is a forbidden portion of the GSO arc, it is obvious that with the elimination of this limitation networks meeting the Annex 1 pfd mask, can be placed there including arc section, where there is no protection (42.7ºW, 39.2ºW), and thus can cause to the network with "small" antenna interference that exceeds the value ($\Delta T/T$ = 6%) with maximum value of −135.72 dBW/27 MHz.

For eastern adjacent forbidden portion of the orbital arc.

TABLE A6-15A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
37.2ºW	(36W, 33.5W)/2.5°	(35W, 33.5W)/1.5°	−135.72/41.27%
36.6ºW	(36W, 33.5W)/2.5° (32.5W, 30W)/2.5°*	(34.6W, 33.5W)/1,1° (32.5W, 31.1W)/1.4°	−138.82/20.22% −137.22/29.23%
36ºW	(36W, 33.5W)/2.5° (32.5W, 30W)/2.5°	(34W, 33.5W)/0.5° (32.5W, 31.1W)/1.4°	−141.90/9.95% −135.72/41.27%

* For this position (and further, where the information for 2 sites is given), the result for the adjacent forbidden portion, as well as the result for the next forbidden portion is given, since when placing the network in it the generated interference will be higher than from the network located in the neighboring forbidden portion.

As can be seen from Table A6-15A, the forbidden arc portion (36W, 33.5W) can be reduced in relation to maintaining the same level of protection for a station with antenna of 40 cm size.

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-15B

Considered position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
37.2W	−135.72	−135.72	−132.72	-	−135.96	−135.96	3.25
36.6W	−135.72	−138.82 −137.22	−133.99 −133.39	-	−135.72	−135.72	1.72 2.32
36W	−135.72	−141.90 −135.72	−134.78 −132.72	-	−136.27	−136.27	1.49 3.56

The value of Δ is defined as (Σ forbidden - Σ allowed).

1.4.7.3.2 Analysis of forbidden portions (36W, 33.5W) and (32.5W, 30W), adjacent to the allowable arc portion [33.5, 32.5]W

For western adjacent forbidden portion of the orbital arc.

TABLE A6-16A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
33.5W	(36W, 33.5W)/2.5° western from 37.2W	(36W, 35.5W)/0.5° (39W, 37.2W)/1.8°	−141.90/9.95% −135.96/39.05%
33W	(36W, 33.5W)/2.5° western from 37.2W	(36W, 35W)/1° (38.5W, 37.2W)/1.3°	−139.38/17.78% −137.57/26.96%
32.5W	(36W, 33.5W)/2.5°	(36W, 34.5W)/1.5°	−136.4/35.31%

For eastern adjacent forbidden portion of the orbital arc.

TABLE A6-16B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
33.5W	(32.5W, 30W)/2.5°	(31.5W, 30W)/1.5°	−136.4/35.3%
33W	(32.5W, 30W)/2.5° (29W, 26W)/3°	(31W, 30W)/1° (29W, 28.5W)/1.5°	−139.38/17.78% −136.88/31.59%
32.5W	(32.5W, 30W)/2.5° (29W, 26W)/3°	(30.5W, 30W)/0.5° (29W, 27W)/2°	−141.9/9.95% −135.73/41.27%

As can be seen from Tables A6-16A and A6-16B, the considered forbidden arc portions can be reduced while maintaining the same protection level to the station with the antenna 40 cm of size in the considered GSO positions.

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-16C

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑ forbid	max I west	max I east	∑ allowed	
33.5W	−141.9 −135.96	−136.40	−135.32 −133.16	−135.72	−135.72	−132.7	−2.61 −0.45
33W	−139.38 −137.57	−139.38 −136.88	−136.37 −134.2	−135.72	−135.72	−132.7	−3.66 −1.49
32.5W	−136.4	−141.9 −135.72	−135.32 −133.04	−135.72	−136.27	−132.97	−2.34 −0.06

1.4.7.3.3 Analysis of forbidden portions (32.5W, 30W) and (29W, 26W), adjacent to the allowable arc portion [30, 29]W

For western adjacent forbidden portion of the orbital arc.

TABLE A6-17A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
30W	(32.5W, 30W)/2.5° (36W, 33.5W)/2.5°	(32.5W, 32W)/0.5° (35.5W, 33.5W)/2°	−141.9/9.95% −135.72/41.27%
29.5W	(32.5W, 30W)/2.5° (36W, 33.5W)/2°	(32.5W, 31.5W)/1° (35W, 33.5W)/1.5°	−139.38/17.78% −136.88/31.59%
29W	(32.5W, 30W)/2.5°	(32.5W, 31W)/1.5°	−136.4/35.3%

For eastern adjacent forbidden portion of the orbital arc.

TABLE A6-17B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
30W	(29W, 26W)/3°	(28W, 26W)/2°	−135.72/41.27%
29.5W		(27.5W, 26W)/1.5°	−136.4/35.31%
29W		(27W, 26W)/1°	−139.4/17.78%

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-17B

Consid position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
30W	−141.9 −135.72	−135.72	−134.79 −132.7	−136.27	−136.82	−133.528	−1.26 0.82
29.5W	−139.38 −136.88	−136.4	−134.63 −133.62	−135.72	−135.72	−132.713	−1.92 −0.91
29W	−136.4	−139.4	−134.63	−135.72	−135.72	−132.713	−1.92

1.4.7.3.4 Analysis of forbidden portions (29W, 26W) and (24W, 20W), adjacent to the allowable arc portion [26, 24]W

For western adjacent forbidden portion of the orbital arc.

TABLE A6-18A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
26W	(29W, 26W)/3° (23.5W, 30W)/3.5°	(29W, 28W)/1º (31.5W, 30W)/1.5°	−139.38/17.78% −136.88/31.59%
25W	(29W, 26W)/3°	(29W, 27W)/2º	−135.72/41.27%
24W	(29W, 26W)/3°	(29W, 26W)/3º	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc.

TABLE A6-18B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
26W	(24W, 20W)/4°	(24W, 20.5W)/3.5°	−135.72/41.27%
25W		(23W, 20W)/3°	−135.72/41.27%
24W		(22W, 20W)/2°	−135.72/41.27%

Table A6-18C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-18C

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
26W	−139.38 −136.88	−135.72	−134.17 −133.25	−135.72	−144.05	−135.12	0.96 1.88
25W	−135.72	−135.72	−132.7	−136.82	−141.03	−135.42	2.71
24W	−135.72	−135.72	−132.7	−141.03	−136.82	−135.42	2.71

1.4.7.3.5 Analysis of forbidden portions (24W, 20W) and (18W, 14W), adjacent to the allowable arc portion [20, 18]W

For western adjacent forbidden portion of the orbital arc.

TABLE A6-19A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
20W	(24W, 20W)/4°	(24W, 22W)/2°	−135.72/41.27%
19W		(24W, 21W)/3°	−135.72/41.27%
18W		(23.5W, 20W)/3.5°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-19B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
20W	(18W, 14W)/4°	(18W, 14.5W)/3.5°	−135.72/41.27%
19W		(17W, 14W)/3°	−135.72/41.27%
18W		(16W, 14W)/2°	−135.72/41.27%

Table A6-19C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-19C

Consid position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
20W	−135.72	−135.72	−132.7	−136.82	−144.05	−136.07	3.36
19W	−135.72	−135.72	−132.7	−141.03	−141.03	−138.02	5.31
18W	−135.72	−135.72	−132.7	−144.05	−136.83	−136.07	3.36

1.4.7.3.6 Analysis of forbidden portions (18W, 14W) and (12W, 8W), adjacent to the allowable arc portion [14, 12]W

For western adjacent forbidden portion of the orbital arc

TABLE A6-20A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
14W	(18W, 14W)/4°	(18W, 16W)/2°	−135.72/41.27%
13W		(18W, 15W)/3°	−135.72/41.27%
12W		(17.5W, 14W)/3.5°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-20B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
14W	(12W, 8W)/4°	(12W, 8.5W)/3.5°	−135.72/41.27%
13W		(11W, 8W)/3°	−135.72/41.27%
12W		(10W, 8W)/2°	−135.72/41.27%

Table A6-20C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-20C

Consid position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
14W	−135.72	−135.72	−132.7	−136.82	−144.05	−136.07	3.36
13W	−135.72	−135.72	−132.7	−141.03	−141.03	−138.02	5.31
12W	−135.72	−135.72	−132.7	−144.05	−136.82	−136.07	3.36

1.4.7.3.7 Analysis of forbidden portions (12W, 8W) and (6W, 4W), adjacent to the allowable arc portion [8, 6]W

For western adjacent forbidden portion of the orbital arc

TABLE A6-21A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
8W	(12W, 8W)/4°	(12W, 10W)/2°	−135.72/41.27%
7W		(12W, 9W)/3°	−135.72/41.27%
6W		(11.5W, 8W)/3.5°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-21B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
8W	(6W, 4W)/2°	(6W, 4W)/2°	−135.72/41.27%
7W	(6W, 4W)/2° (4W, 2W)/2°	(5W, 4W)/1° (4W, 2W)/2°	−139.27/18.23% −135.72/41.27%
6W	(6W, 4W)/2° (4W, 2W)/2°	(5W, 4W)/1° (4W, 2W)/2°	−144.2/5.85% −135.73/41.27%

Table A6-21C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-21C

Consid position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
8W	−135.72	−135.72	−132.7	−136.82	−136.82	−133.81	1.1
7W	−135.72	−139.27 −135.72	−134.13 −132.7	−141.03	−139.27	−137.05	2.91 4.34
6W	−135.72	−144.2 −135.72	−135.15 −132.7	−144.05	−143.88*	−140.95	5.8 8.24

* In the next allowable (4W, 2W) arc portion the maximum value of the allowed by Annex 1 interference is −136.82 dBW/27 MHz and ΔT/T = 32.06%, then in this case Δ is equal to 0.92 and 3.35 dB, respectively.

1.4.7.3.8 Analysis of forbidden portions (6W, 4W) and (4W, 2W), adjacent to the allowable arc portion [4]W

For western adjacent forbidden portion of the orbital arc

TABLE A6-22A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
4W	(6W, 4W)/2° (12W, 8W)/4°	-/0° (10W, 8W)/2°	−144.2/5.85% −136.88/31.59%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-22B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/Δ*T/T*
4W	(4W, 2W)/2° (0W, 4E)/4°	-/0° (0W, 1.5W)/1.5°	−144.2/5.85% −136.88/31.59%

Table A6-22C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-22C

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
4W	−144.2 −136.88	−144.2 −136.88	−141.19 −133.87	−135.72	−135.72	−132.7	−8.48 −1.16

1.4.7.3.9 Analysis of forbidden portions (4W, 2W) and (0W, 4E), adjacent to the allowable arc portion [2, 0]W

For western adjacent forbidden portion of the orbital arc

TABLE A6.23A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
2W	(4W, 2W)/2° (6W, 4W)/2°	-/0° (6W, 4W)/2°	−144.2/5.85% −135.72/41.27%
1W	(4W, 2W)/2° (6W, 4W)/2°	(4W, 1W)/1° (6W, 4W)/2°	−139.38/17.78% −135.72/41.27%
0W	(4W, 2W)/2°	(4W, 2W)/2°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-23B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
2W	(0W, 4E)/4°	(0W, 3.5E)/3.5°	−135.72/41.27%
1W		(1E, 4E)/3°	−135.72/41.27%
0W		(2E, 4E)/2°	−135.72/41.27%

Table A6-23C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-23C

Considered position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
2W	−144.2 −135.72	−135.72	−135.14 −132.7	−143.88	−144.05	−140.95*	5.8 8.24
1W	−139.38 −135.72	−135.72	−134.16 −132.7	−139.27	−141.03	−137.05	2.88 4.34
0W	−135.72	−135.72	−132.7	−136.82	−136.82	−133.81	1.07

* In the next allowable (8W, 6W) arc portion, the maximum value of the interference allowed by Annex 1 is −136.82 dBW/27 MHz and $\Delta T/T$ = 32.06%, in this case Δ is equal to 0.92 and 3.35 dB, respectively.

1.4.7.3.10 Analysis of forbidden portions (0W, 4E) and (6E, 9E), adjacent to the allowable arc portion [4, 6]E

For western adjacent forbidden portion of the orbital arc

TABLE A6-24A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
4E	(0E, 4E)/4°	(0E, 2E)/2°	−135.72/41.27%
5E		(0E, 3E)/3°	−135.72/41.27%
6E		(1/5E, 4E)/2°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-24B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
4E	(6E, 9E)/3°	(6E, 9E)/3°	−135.72/41.27%
5E	(6E, 9E)/3°	(7E, 9E)/2°	−135.72/41.27%
6E	(6E, 9E)/3° eastern than 9°	(8E, 9E)/1° (9E, 11.5E)/2.5°	−139.38/17.77% −135.72/41.27%

Table A6-24C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-24C

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
4E	−135.72	−135.72	−132.7	−136.82	−141.03	−135.42	2.71
5E	−135.72	−135.72	−132.7	−141.03	−136.82	−135.72	2.71
6E	−135.72	−139.38 −135.72	−134.16 −132.7	−144.05	−139.27	−138.02	3.85 5.31

1.4.7.3.11 Analysis of forbidden portions (6E, 9E) and (9E, 10E), adjacent to the allowable arc portion [9]E

For western adjacent forbidden portion of the orbital arc

TABLE A6-25A

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
9E	(6E, 9E)/3°	(6E, 7E)/2°	−139.38/17.77%

For eastern adjacent forbidden portion of the orbital arc

TABLE A6-25B

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
9E	(9E, 10E)/1°	-/0°	−144.2/5.85%

Table A6-25C compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

TABLE A6-25C

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
9E	−139.38	−144.2	−138.14	−135.72	−135.72	−132.7	−5.4

1.4.7.4 Existing protection provided by forbidden arc portions to filed networks with "small" antennas

Since the BR has already received filings for frequency assignments with small antennas for GSO positions within the allowable portions of orbital arc, is of interest to analyse the existing levels of protection by forbidden orbital arc portions of such assignments. Below are the study results for three specific GSO positions (30W, 33.5W and 5E), where there are filings with small antennas: of 45 cm and 40 cm sizes, respectively.

Plots of allowed by Annex 1 interference level and ΔT/T for considered in this section cases are presented in Study #3, § 1.4.6.

For GSO position 33.5W (45 cm antenna)

For western adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
33.5W	(36W, 33.5W)/2.5° western from 37.2W	(36W, 35.5W)/0.5° (38.5W, 37.2W)/1.3°	−142.08/9.54% −137.7/26.17%

For eastern adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
33.5W	(32.5W, 30W)/2.5°	(31.5W, 30W)/1.5°	−142.08/9.54%

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑ forbid	max I west	max I east	∑ allowed	
33.5W	−142.08 −137.7	−142.08	−139.07 −136.35	−137.23	−137.23	−134.2	−4.85 −2.12

For GSO position 30W (45 cm antenna)

For western adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
30W	(32.5W, 30W)/2.5° (36W, 33.5W)/2.5°	(32.5W, 32W)/0.5° (35W, 33.5W)/1.5°	−142.08/9.54% −137.23/29.17%

For eastern adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
30W	(29W, 26W)/3°	(28W, 26W)/2°	−137.23/29.17%

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
30W	−142.08 −137.7	−142.08	−139.07 −136.35	−137.64	−138.93	−135.22	−3.84 −1.12

For GSO position 5E (40 cm antenna)

(See § 3.10 above)

For western adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
5E	(0E, 4E)/4°	(0E, 3E)/3°	−135.72/41.27%

For eastern adjacent forbidden portion of the orbital arc

Considered position of allowable portion	Adjacent forbidden portion/portion size	Piece of forbidden portion providing protection/piece size	Maximum allowed interference caused by network in forbidden portion/ΔT/T
5E	(6E, 9E)/3°	(7E, 9E)/2°	−135.72/41.27%

The Table below compares the maximum allowed by Annex 1 interference levels from possible networks in adjacent allowable and forbidden arc portions.

Consid. position	Forbidden portion			Allowable portion			Δ, dB
	max I west	max I east	∑forbid	max I west	max I east	∑allowed	
5E	−135.72	−135.72	−132.7	−141.03	−136.82	−135.72	2.71

Conclusion on section 4: As can be seen from the analysis for an antenna of 45 cm diameter in the considered GSO orbital positions there will be no increase in the interference level in the event of the cancellation of forbidden arc portions and in case the new network is placed at the worst point. For antennas with of 40 cm diameter an increase in the interference level to 2.71 dB is possible provided that new networks are located at the worst points of forbidden arc portions in terms of the interference level caused.

Analysis demonstrates the following possible decreasing of forbidden arc portions to that part where ΔT/T<= 6% without worsening interference situation for considered specific cases:

GSO pos.		Western portions		Eastern portions	
33.5W	Current forbidden arc portion	36W – 33.5W		32.5W – 30W	29W – 26W
	Reduced forbidden arc portion	36W − 35.5W		31.5W – 30W	29W – 28.5W
30W	Current forbidden arc portion	36W – 33.5W	32.5W – 30W	29W – 26W	
	Reduced forbidden arc portion	35W – 33.5W	32.5W – 32W	28W – 26W	
5E	Current forbidden arc portion	0E – 4E		6E – 9E	
	Reduced forbidden arc portion	0E – 3E		7E – 9E	

1.4.7.5 Heat maps of interference levels (ΔT/T)

The presented interference analysis for the separate GSO positions in the allowable arc portions where the network with “small” antenna is located, does not give a complete picture of the interference situation. Interference heatmaps presented below give an idea of the interference levels for all possible combinations of the mutual placement of a pair of wanted and interfering networks, both for cases where both networks are located in the allowable arc portions, or for cases where only one of the two networks is in the allowable portion, and the other −in the forbidden. The heatmap allows to see in fact a 3D picture of the interference, showing the allowable by Annex 1 interference level with different colors, as a function of the position of the two networks on the GSO orbital arc (the colors correspondence to the interference levels (ΔT/T) is shown in the Figure).

The heat maps are provided for antennas with 40 cm diameter (Fig. A6-38 (both networks are in allowable portions, Fig. A6-39 (one network – in allowable, the other – in forbidden arc portions) and 45 cm (Fig. A6-40 (both networks are in the allowable portions, Fig. A6-41. The maps are for antennas with a diameter of 40 cm (Figure A6-38 (both networks are in permitted areas, Fig. A6-39) and 45 cm (Fig. A6-40 (both networks are in the permitted areas, Fig. A6-41)).

Figures A6-42 and A6-43 show the heat maps for the two selected pairs of zones for the case of antenna with 40 cm of diameter.

For the allowable arc portions [4E, 6E], [2W, 0W], the probability of causing interference exceeding 6% with the random placement of satellites within these zones is 30.8% (Fig. A6-42). Similarly, for arc portions [26W, 24W] and [30W, 29W], the probability of causing interference exceeding 6% with random placement of satellites within these zones is 93.5% (Fig. A6-43).

Figures A6-44 and A6-45 show the heat maps for the same two selected pairs of zones for the case of antenna with 45 cm of diameter.

For the allowable arc portions [4E, 6E], [2W, 0W], the probability of causing interference exceeding 6% with the random placement of satellites within these zones is 10.2% (Fig. A6-44). Similarly, for arc portions [26W, 24W] and [30W, 29W], the probability of causing interference exceeding 6% with random placement of satellites within these zones is 66.7% (Fig. A6-45).

FIGURE A6-38

Antenna 40 cm – wanted and interfering networks in allowable arc portions

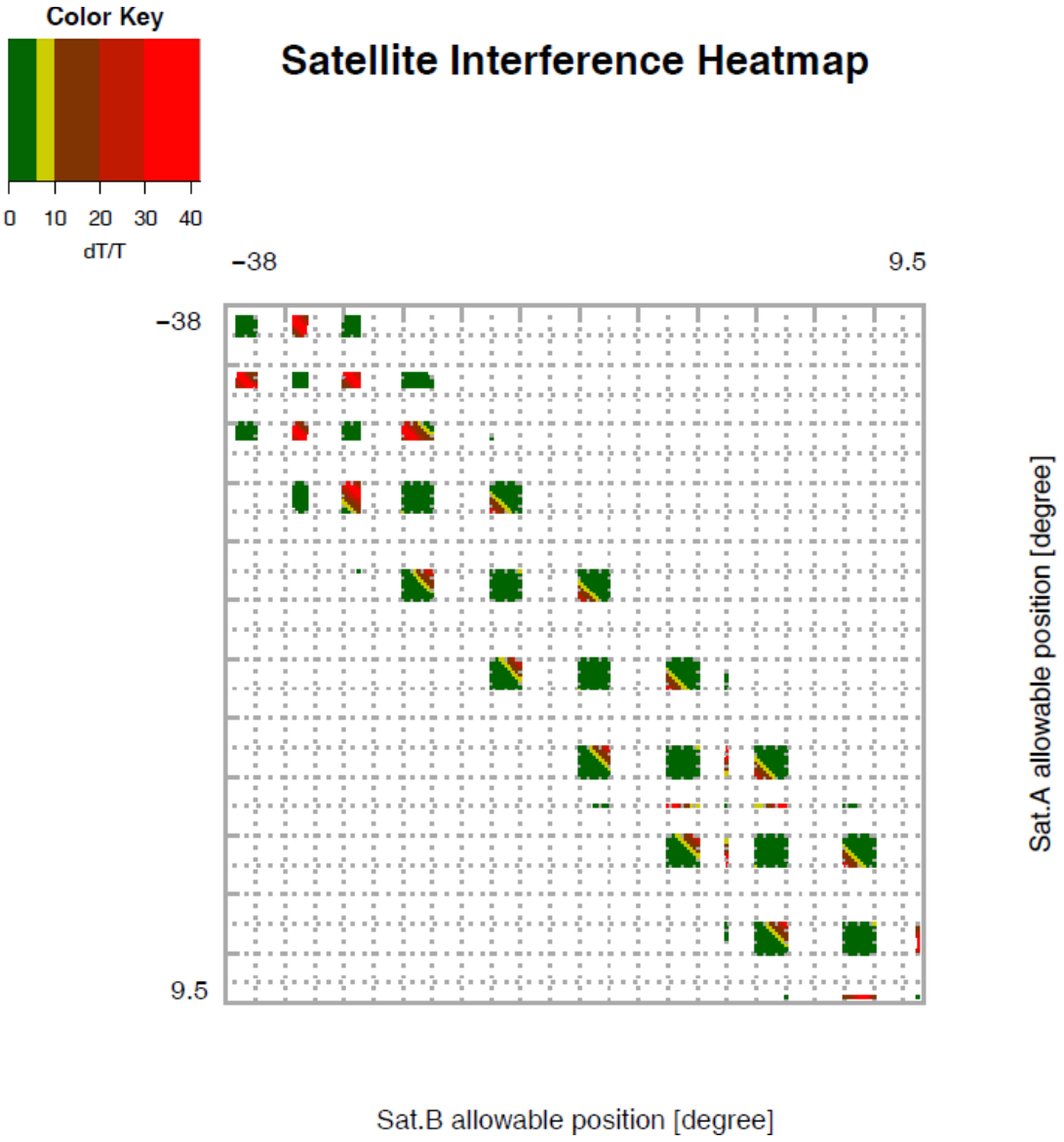


FIGURE A6-39

Antenna 40 cm – wanted network in allowable arc portions, interfering network in forbidden arc portions

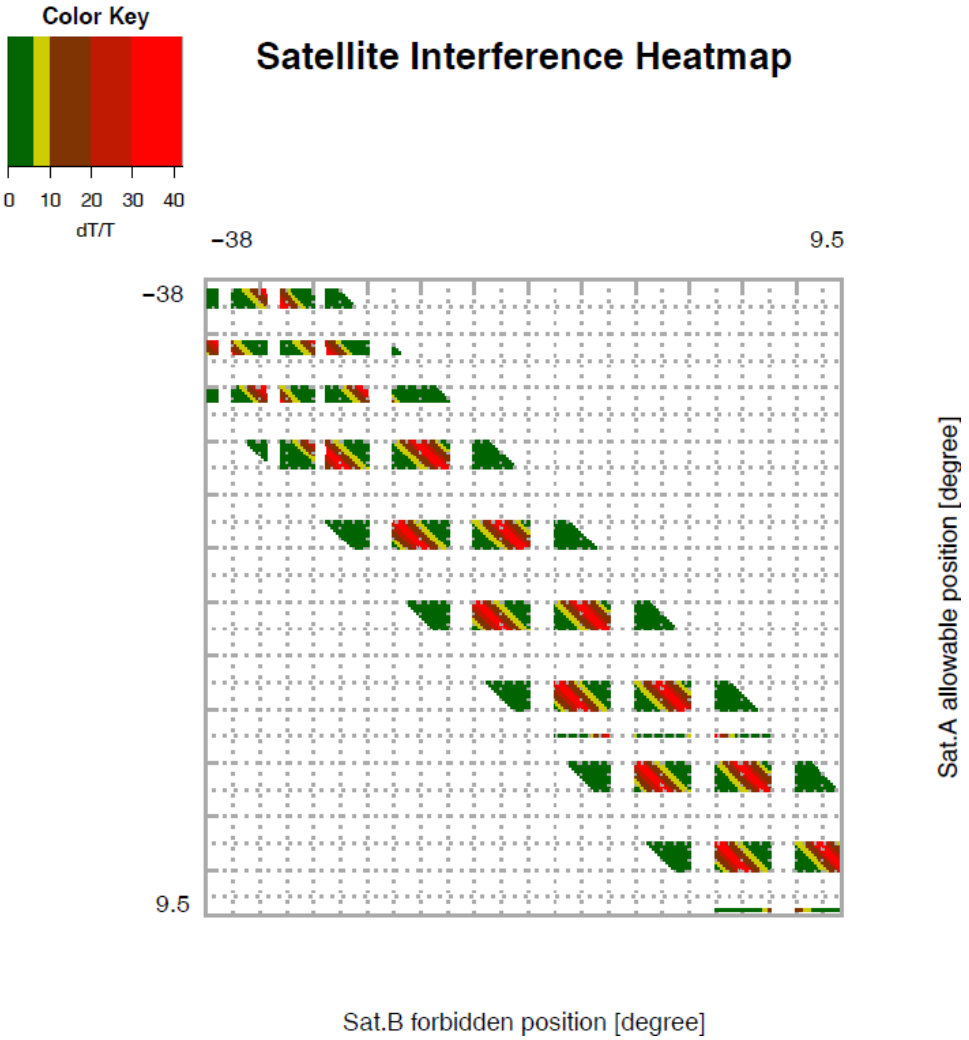


FIGURE A6-40

Antenna 45 cm – wanted and interfering networks in allowable arc portions

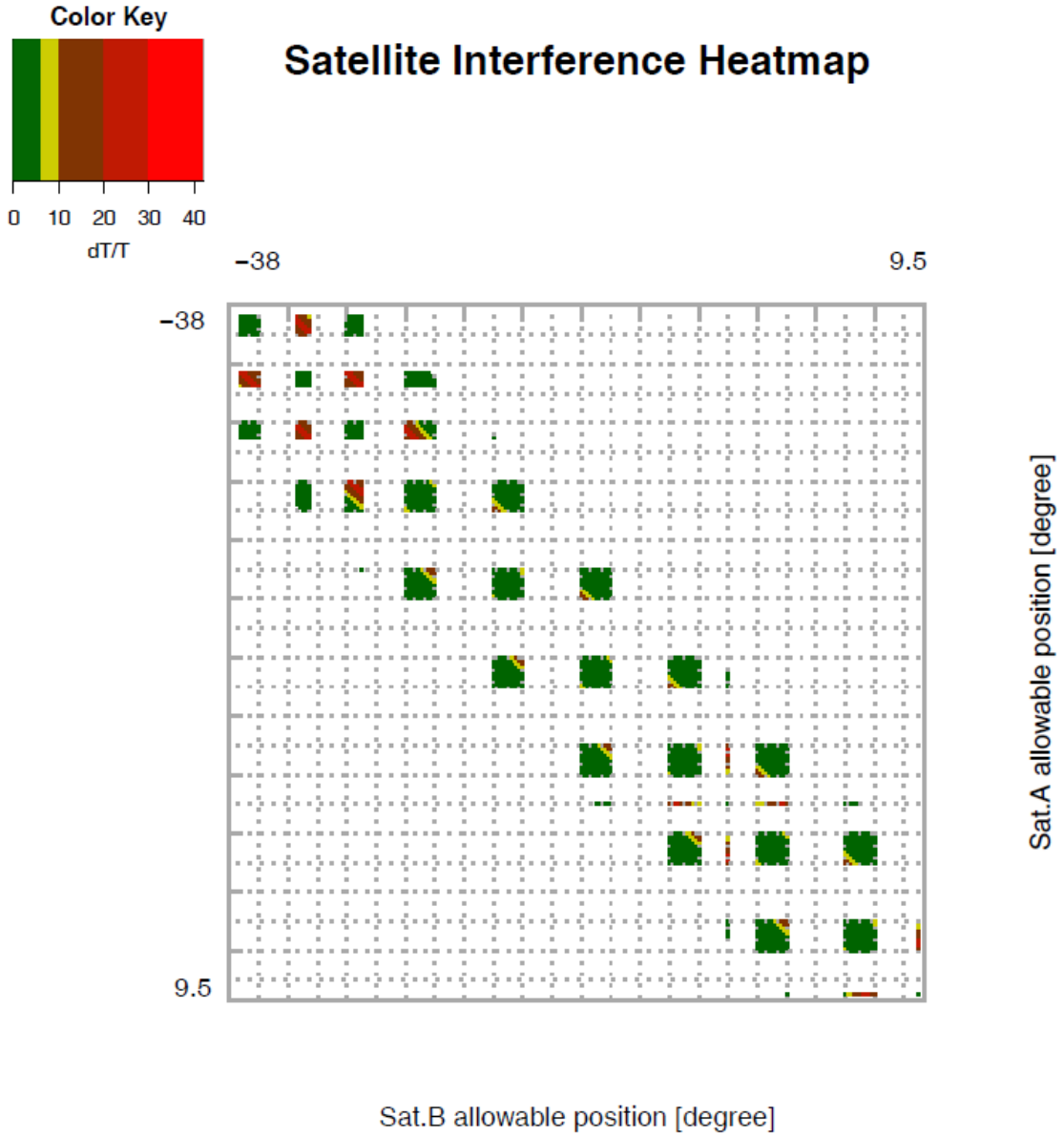


FIGURE A6-41

Antenna 45 cm – wanted network in allowable arc portions, interfering network in forbidden arc portions

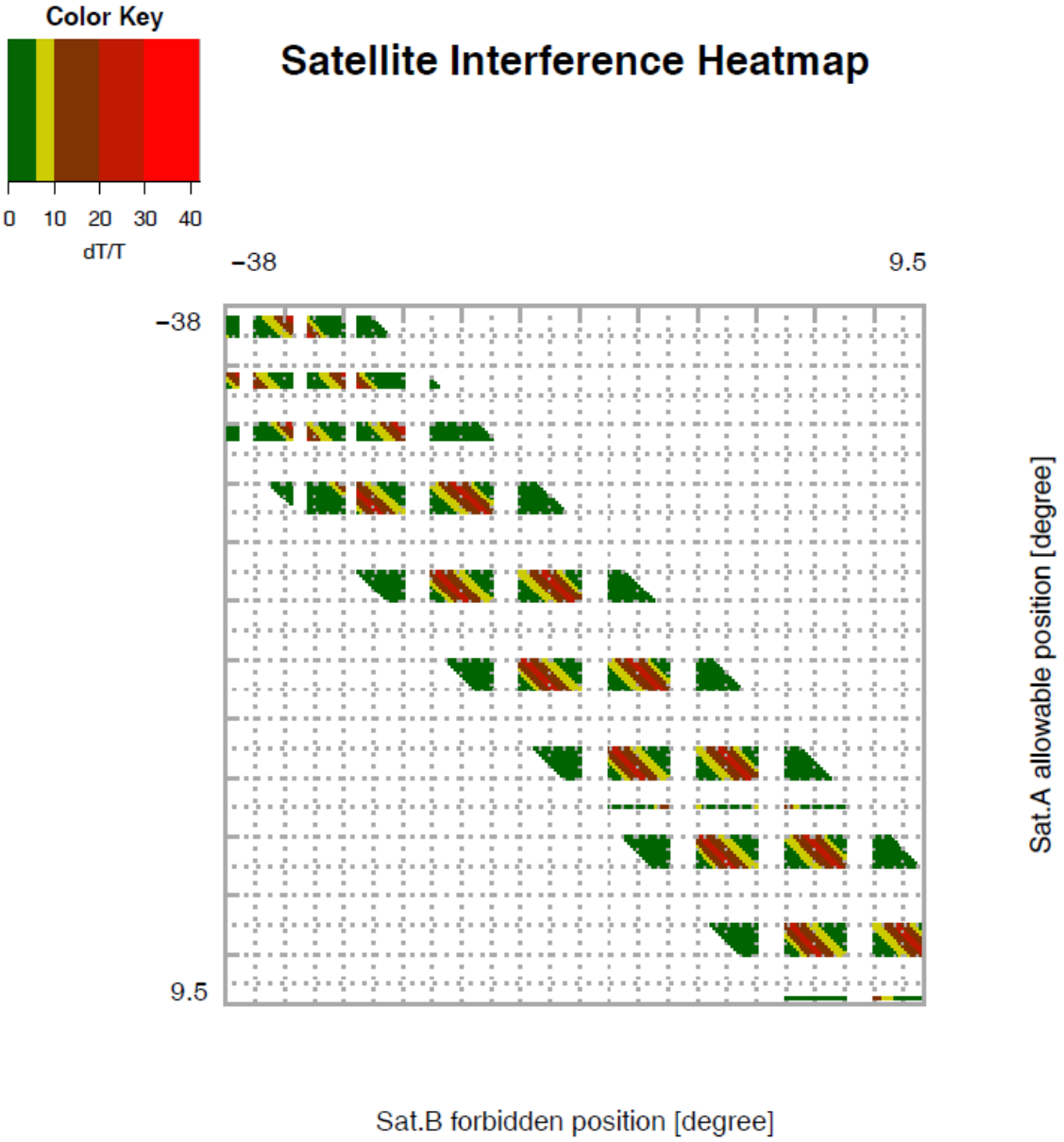


FIGURE A6-42
(40 CM ANTENNA)

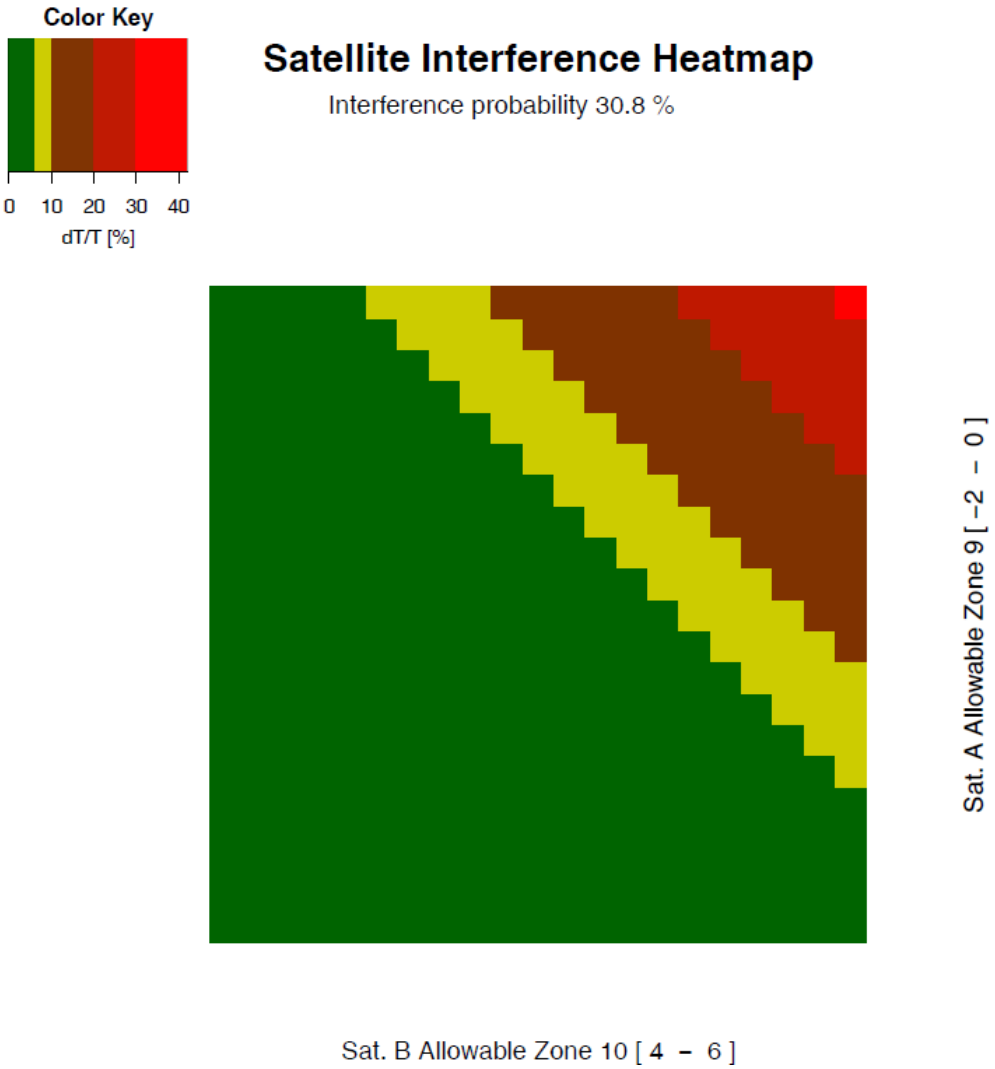


FIGURE A6-43
(40 CM ANTENNA)

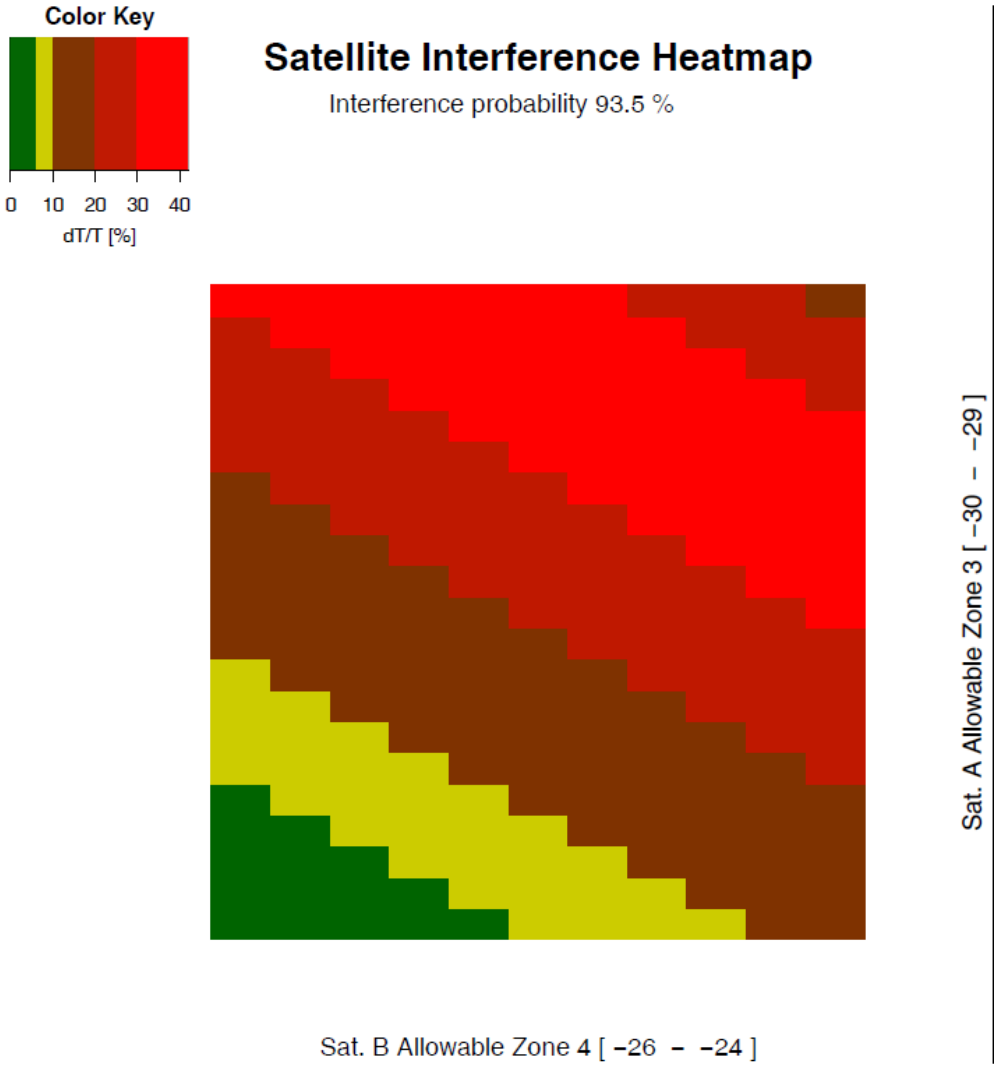


FIGURE A6-44
(45 CM ANTENNA)

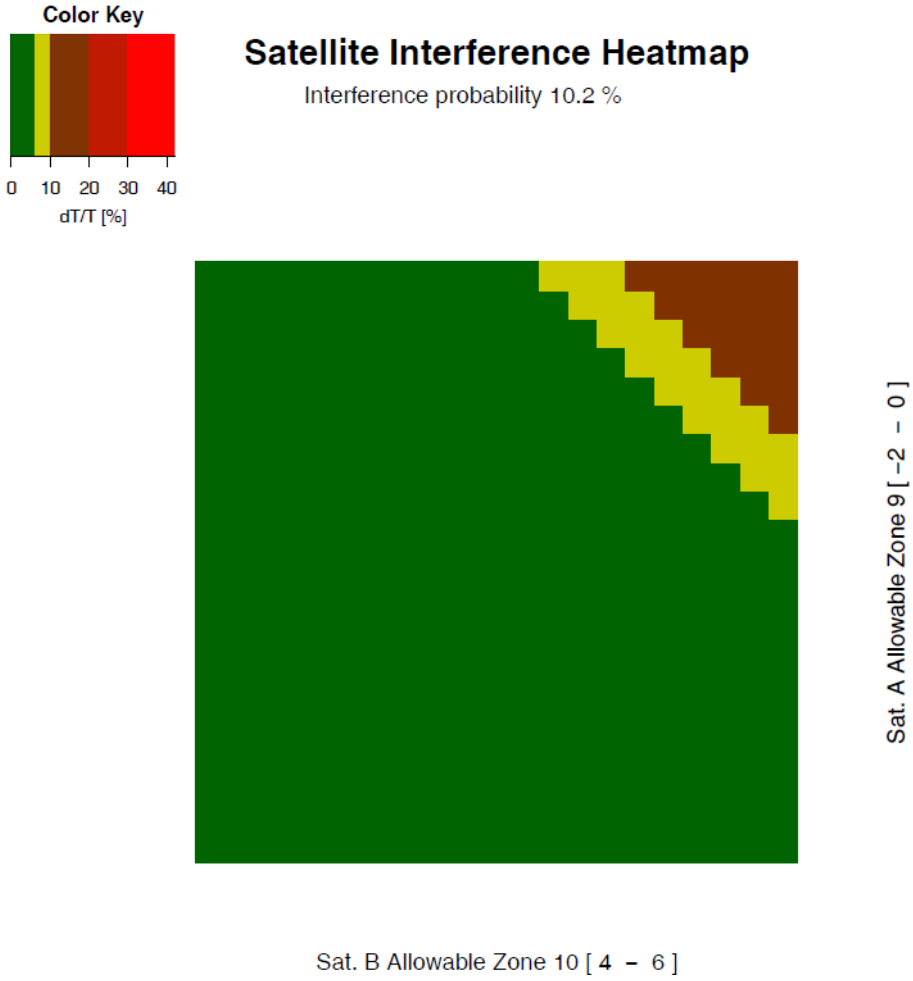
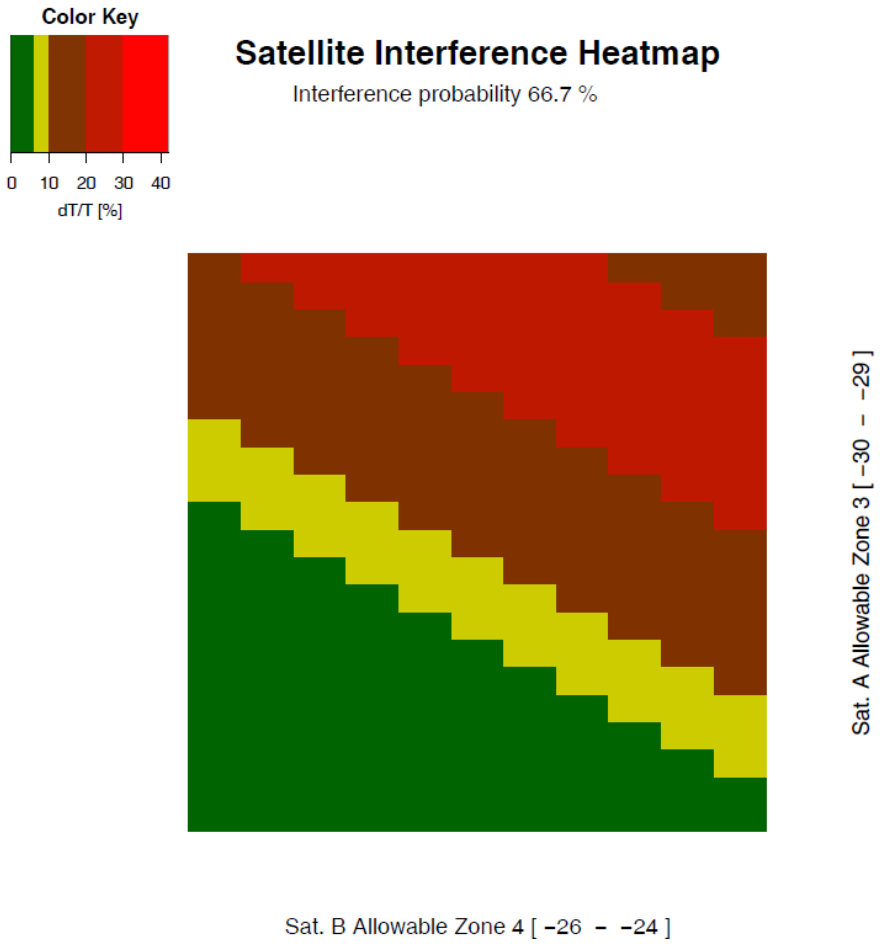


FIGURE A6-45
(45 CM ANTENNA)



The interference heatmap for antenna of 40 cm diameter and a pair of satellites located in the allowable arc portions shows the presence of significant areas (about 30% or more) in the allowable arc portions where the interference level exceeds 6%. The exceptions are cases where both networks are in the same allowable arc portion. In this case, the interference level does not exceed 6% at any position of the satellites.

When one of the satellites is placed in the forbidden arc portion, we also see vast areas where the interference level exceeds the allowable level.

Thus, by itself, the presence of forbidden arc portions does not guarantee ensuring the interference level to earth stations with “small” antennas at the level of 6%.

For earth stations with antennas of 45 cm size, interference areas exceeding 6% are somewhat smaller than those for antennas of 40 cm size.

1.4.8 Results of study #3

As seen from the above considerations, under the current regulatory framework there is no allowable portion of the orbital arc (Table 1 Annex 7), where an earth station using antenna size of 40 cm, had guaranteed protection at 6% by pfd mask of Annex 1, as in all adjacent allowable portions of the orbital arc there are positions such that a new assignment being in compliance with Annex 1 pfd limits filed in these positions would cause interference, the value permissible interference criterion $\Delta T/T$ exceeds 6%, maximum possible $\Delta T/T$=~41% from networks in the adjacent allowable portions of arc.

Analysis of forbidden arc portions showed, that in most cases only a part of the forbidden arc portion protects the network with “small” antenna, and therefore the "unprotecting" part of the forbidden arc portion can be eliminated from the point of view of preserving the protection of implemented[5] networks with “small” antennas from networks complying with Annex 1 pfd mask. The boundaries of the section of the forbidden portion that does not participate in the protection of station with “small” antenna should be determined for the each specific case of the network location.

The analysis and presented interference heatmaps clearly showed the presence of possible allowed by Annex 1 interference exceeding 6% that must be accepted, both from networks in allowable arc portions, and from networks in forbidden arc portions. In both cases, various levels of interference up to the maximum values ($\Delta T/T$ to 32-41%) are predicted and which must be accepted as caused by Annex 1 pfd mask compliant networks. Therefore, it cannot be claimed that forbidden arc portions always provide protection that compensates lower selectivity ranges for a station with a ‘small’ antenna. The presence of forbidden arc portions only reduces the probability of causing interference greater than 6% by networks in compliance with Annex 1 pfd mask.

In view of those findings, it seems unreasonable to develop some general mandatory measures to protect stations with “small” antennas from networks complying with Annex 1 pfd mask. The situation with protection from Annex 1 pfd mask compliant networks in forbidden arc portions varies depending on mutual GSO position of wanted and interfering networks.

In other words, the presence of forbidden arc portions somewhat improves the protection of networks with ‘small’ antennas from interference, but does not solve the problem radically.

Therefore, solution for protection from networks complying with Annex 1 pfd mask must be determined individually for each implemented[6] network with ‘small’ antenna. It is not accurate to talk about protection in general, since the predicted interference level from networks in compliance with Annex 1 pfd mask varies from 6 to 41%.

1.5 Study #4: Protection of 45 cm receiving earth station antennas used by BSS networks in Region 1

Additional issue that has to be carefully treated is the usage of Region 1 planned BSS networks employing receiving earth station antennas with the diameter of 45 cm. Some Region 1 BSS networks that employ such receiving earth station antennas are already included in the Regions 1 and 3 BSS List of Appendix **30**. Some of them have already been notified and brought into use.

Having in mind the text of Resolution **557 (WRC-15)**, in particular the part mentioning the need to “ensure the protection of, and without imposing additional constraints on, assignments in the BSS Plan and the BSS List and the future development of the BSS”, it is obvious that the protection of all notified BSS networks, even the ones employing 45 cm receiving earth station antennas, should be assured by any revision of the Annex 7 text.

However, it has to be stressed that the current pfd masks that serve for the protection of Regions 1 and 3 planned BSS networks from unplanned FSS networks operating in another Region (Annex 4 to Appendix **30**) and from planned BSS networks operating in another Region (section 3 of Annex 1 to Appendix 30) do not include the protection of receiving earth station antennas of 45 cm.

The pfd masks for the protection of BSS networks in different Regions are shown in Fig. A6-46.

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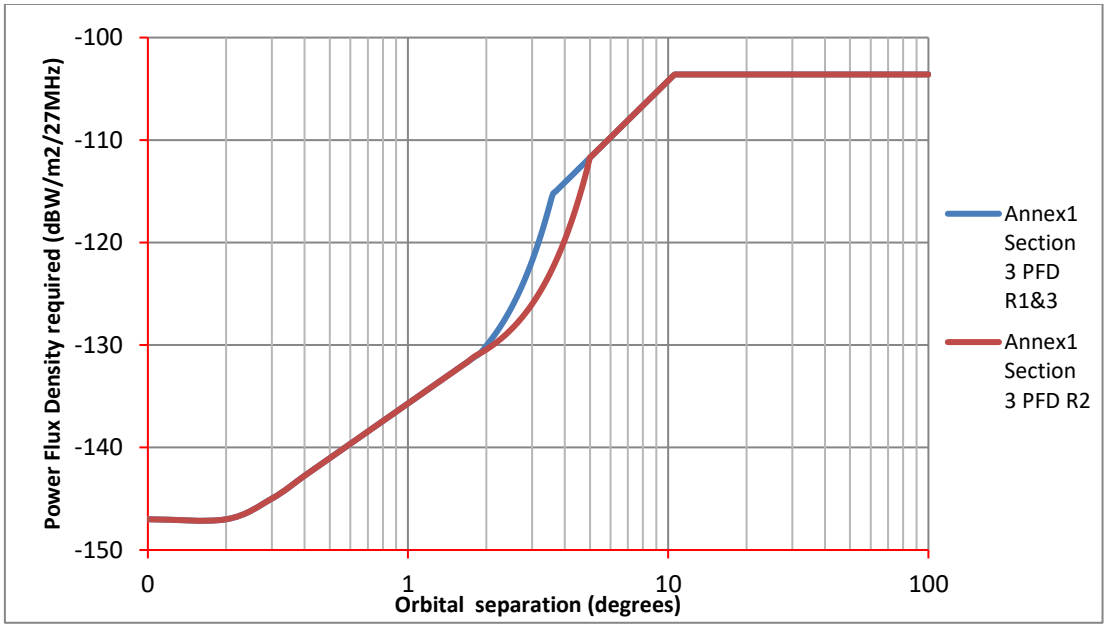
5 See § 4.3 of this Report.

6 See § 4.3 of this Report.

FIGURE A6-46

Comparison of pfd masks for planned BSS networks protection in different regions



The details of pfd masks contained in section 3 of Annex 1 to Appendix **30** are presented. It has to be noted that these pfd masks are exactly the same as the pfd masks in section 6 of Annex 1 to Appendix **30**.

Therefore, it can be concluded that by using the existing pfd masks the protection of planned BSS networks in Region 1 and 3 employing the receiving earth station antennas of 45 cm of diameter cannot be assured.

The current pfd masks were adopted at WRC-2003 conference. These masks represent the envelope of numerous pfd masks corresponding to a range of receiving earth station antenna diameters.

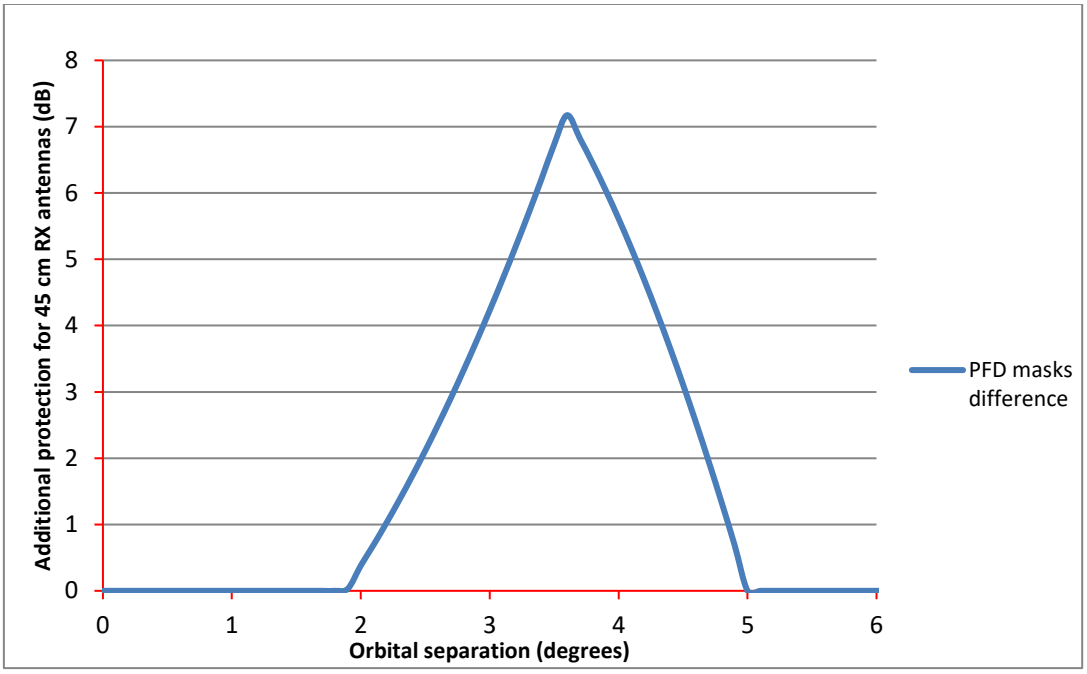
For the protection of Regions 1 and 3 planned BSS networks the range of receiving earth station diameters from 60 cm to 240 cm was taken into account. For the protection of Region 2 planned BSS networks the range of receiving earth station diameters that taken into account in the preparation of the pfd masks was from 45 cm to 240 cm.

The difference of protection between 60 cm and 45 cm receiving earth station antennas (difference between current pfd masks) is indicated in Fig. A6-47.

Figure A6-47 shows that between 2° and 5° of orbital separation the 45 cm receiving earth station antenna needs up to 7.2 dB bigger protection, hence more stringent pfd mask.

FIGURE A6-47

Difference of protection for planned BSS networks operating in different Regions



The current pfd masks for Region 1 and 3 planned BSS networks protection (section 3 of Annex 1 to Appendix **30**, and Annex 4 of Appendix **30**) were based on noise increase of 6%. That implies that the usage of current pfd masks for the protection of Region 1 BSS receiving earth station antennas of 45 cm allows much higher noise increase to such BSS network for orbital separations 2° to 5°, without triggering the corresponding pfd threshold value.

Knowing that the majority of coordination situations lie in this orbital separation range, it is of paramount importance to understand the adverse practical effect of current pfd masks application for the protection of such receiving earth station antennas.

In addition to that, it has to be mentioned that current Region 2 BSS Plan protection from all new Region 1 and 3 BSS List networks could be efficiently achieved even with a pfd mask based on receiving earth station antenna of 60 cm.

The most western orbital positions used by the Region 2 BSS Plan (31°W, 33.8°W and 42.2°W) are used only by Region 2 original BSS Plan assignments based on 1 m receiving earth station antenna diameter. As the orbital arc 44°W – 37.2°W (6.8° spacing) is forbidden for the Regions 1 and 3 BSS networks, as well as for the Region 2 BSS networks, the minimum theoretical spacing between any new planned BSS networks in all Regions in this orbital arc is therefore 6.8 degrees.

For such orbital separation the radiation patterns (and hence protection pfd masks) for 45 cm and 60 cm are exactly the same.

Thus, the pfd protection mask based on receiving earth station diameter of 60 cm would be more than sufficient to protect Region 2 BSS networks from any new Region 1 and 3 BSS network, taking into account current Annex 7 limitations. This implies that the current pfd mask in section 3 of Annex 1 to Appendix **30** is over protective toward Region 2 BSS networks.

All these facts show current discrepancy in practical (over)protection of BSS networks in Region 2 with respect to not sufficient protection of Region 1 and 3 BSS networks if 45 cm receiving earth station antennas are used.

However, in the case of possible revision of part A1 and part A2 limitations of Annex 7, the current pfd mask in section 3 of Annex 1 to Appendix **30** would continue to efficiently protect Region 2 BSS receiving earth station antennas of 45 cm diameter.

1.6 Study #5: Analysis on the use of antenna sizes greater than or equal to 60 cm

Antenna sizes greater than or equal to 60 cm were used to develop the pfd mask for intra-service sharing in BSS in Regions 1 and 3 (i.e. section 1 of Annex 1 of Appendix **30**), therefore the deletion of the Annex 7 limitation "A3a" will not impact Regions 1 and 3 BSS networks.

2 Study #6: Inter-service sharing between Region 1 BSS and Region 2 FSS networks in 11.7-12.2 GHz

Impacts of Region 1 BSS into Region FSS or Region 2 FSS into Region 1 BSS in the arc 37.2ºW – 10ºE are similar to the impacts studied for limitation "A1a" (see Annex 1). In both cases, a Region 1 BSS could be newly located to a position of an existing Region 2 FSS which was not possible according to Annex 7 limitation. Therefore, summary of studies provided in section 2 of Annex 1 are applicable to this case.