Draft CEPT Brief on Agenda Item 1.18

Agenda item 1.18: *to review pfd limits in the band 17.7-19.7 GHz for satellite systems using highly inclined orbits, in accordance with Resolution 141 (WRC-03)*

Issue

As stated in Resolution 141, this agenda item covers the following issues:

1. Consideration of the ITU-R studies to determine whether the current pfd limits for non-GSO systems in the FSS in Article **21** are adequate to protect the fixed service in the 17.7-19.7 GHz band from non-GSO systems using highly-inclined orbits having an apogee altitude greater than 18 000 km and an orbital inclination between 35° and 145°, without unduly constraining the use of these non-GSO FSS systems.

2. Consideration of the ITU-R studies to determine whether there are technical and operational measures in the band 17.7-19.7 GHz that could be implemented in the fixed service to mitigate interference from FSS space stations as described in (1) above.

Preliminary CEPT position

1. On the basis of a large number of studies conducted within CEPT and by other administrations, CEPT considers that the current Article 21 pfd limits are generally not adequate to protect the FS systems in the 17.7-19.7 GHz band from HIO satellite systems[1]. However, for some HIO satellite systems, with specific orbital and operational characteristics (see section 2 below), a tightening of the mask may not be needed.

2. CEPT supports the need for an appropriate regulatory framework within which adequate protection for the FS can be achieved without unduly constraining the FSS systems.

3. CEPT considers that there is clearly no limitation on the eccentricity of the orbit of non-GSO satellite systems referred to in *considering g)* of Resolution 141 (WRC-03). Therefore any circular or elliptical orbit with an inclination between 35° and 145° and apogee altitude greater than 18 000 km should be taken into account

4. CEPT considers the application of the currently proposed mitigation techniques on existing FS links impractical and therefore these mitigation techniques can not be considered when deriving pfd limits for Agenda Item 1.18.

1. Background

1.1 Summary

Within Europe the 17.7-19.7GHz band is extensively used by the FS for low, medium and high capacity links and the band is shared on a co-primary allocation basis with the FSS. USA and Canada are planning for the band to be segmented and for the FSS to become the sole primary allocation in the band 18.3-18.8GHz. The same administrations have proposed to place emphasis on

[1] In this document HIO satellite systems refer to non GSO systems having an apogee altitud grater than 18 000 km and orbital inclination between 35 and 145 as defined in considering g) of Resolution 141.

a designation for FS in the band pairs 17.7-18.14GHz with 19.26-19.7GHz, where sharing with low density FSS use is deemed to be feasible.

In the 2000-2003 study cycle, in the framework of WRC-03 Agenda Item 1.37, WP 4-9S received several contributions containing interference analyses using various methodologies to show the effect on the FS of different pfd masks for satellite systems using highly elliptical orbits. These analyses are brought forward to the present study cycle through Document 4-9S/1. The FS and FSS parameters used in the collected studies, along with the FS protection criteria and methodologies for developing/assessing pfd masks have been reviewed during the 2003-2007 cycle by WP 4-9S, the leading group in ITU-R on WRC-07 Agenda Item 1.18. During the WP4-9S October 2004 meeting, the meeting agreed that there would be a benefit from an agreement on some common parameters for the FS and FSS to be used in further studies (See Table 3, Doc.4-9/166 Annex 4). Nevertheless, there was disagreement regarding the methodology to study the adequacy of the pfd limits in Article 21 to protect the FS from HIO satellite systems (see Sec.1.2 and 1.3 below).

It is to be noted that all the studies conducted by CEPT Administrations, either considering the satellite emitting at the current pfd level or using spot beams (see Sec.1.2 below for further details on these two approaches) show that the current Article 21 pfd limits are not adequate to protect the FS from the HIO systems in the 17.7-19.7 GHz band. It is also to be noted that there is no study presented so far in CEPT or ITU-R that contradicts the fact that, when the satellite is considered as emitting at the current pfd mask, the FS protection criteria are exceeded for large areas of the Earth for a range of FS azimuth directions.The critical points in the framework of WRC-07 Agenda Item 1.18 are discussed below and associated CEPT views are given.

1.2 "PFD mask approach"/ "Spot beam approach"

The use of the pfd mask is the commonly accepted procedure to avoid consideration of the systems specific characteristics. Therefore, CEPT is of the opinion that the use of the pfd mask is the most appropriate approach to assess the suitability of the pfd mask itself as requested under agenda item 1.18. The "pfd mask approach" assumes that the satellite, when active, emits at the current Article 21 pfd mask and satellite antenna characteristics (i.e. roll-off) are deemed to be already included in the mask (lower pfd limit at low angles of arrival).

With the "spot beam approach", only narrow spot beams are considered in the interference studies with various assumptions about pointing directions, transmitted power, etc. The studies become very much system specific, depending on the location of the Earth stations, satellite antenna EIRP, etc., and lose the generality allowed by the use of the PFD mask as a method to identify interference issues. Also, it is not considered desirable or possible to reflect such specific characteristics for each individual system within the regulatory limitations in the Radio Regulations.

Furthermore, a number of studies in CEPT has shown that even the consideration of spot beams complying with the current pfd mask, does not preclude interference occurring above the FS protection criteria threshold.

1.3 Use of Recommendation ITU-R SF.1602: statistical distribution of pfd

CEPT Administrations are of the view that Recommendation ITU-R SF.1602 should not be used in the sharing studies under Agenda Item 1.18 for the following reasons:

- The methodology described in Section 4 of the Recommendation assumes a constant satellite altitude when deriving the pfd distribution. Therefore, this Recommendation refers specifically to satellites in a circular orbit and should only be applied to these satellites.
- The resulting PFD distribution for a given elevation angles is the result of an averaging process in which the satellite beam is pointed in all possible directions. Therefore, this

approach cannot be used to evaluate the pfd in the coverage area associated to a specific Earth Station. In practice, the worst case of an FS receiver in (or in the proximity of) the coverage area of an ES whose elevation angle is relatively low (<25^{o}) is not reflected in this approach.

- The text contained in Appendix 6 to Annex 1 of Rec.SF.1602 may give rise to different interpretation on how to apply the suggested methodology.

1.4 Circular/elliptical orbits

WRC-07 Agenda item 1.18 limits the review of the current non-GSO limits to HIO satellite systems. All CEPT countries agree that the text for Agenda Item 1.18 is clear and encompasses the circular orbit systems meeting the criteria of considering g) of Resolution 141. However, some Administrations outside CEPT are of the view that this characterization is intended to be limited to highly-elliptical orbit systems, as their understanding is that this subject is a continuation of WRC-03 Agenda Item 1.37 which was dealing with HEO. Nevertheless, it should also be noted that WRC-03 made more stringent limits in 10-11-12 GHz band for HIO satellite systems (cf RR n°**21.16.17 "**These limits apply to non-geostationary fixed-satellite service space stations employing an orbit with an inclination angle between 35° and 145° and apogee altitude greater than 18 000 km. (WRC-03)"). This is why WRC-07 agenda item 1.18 was referring to HIO satellite systems.

1.5 FS antenna gain and elevation statistics

To conduct the FS/FSS sharing studies, it was agreed within CEPT and also within ITU-R, to take three values of antenna gain (32, 38 and 48 dBi) and three values of FS antenna elevation angle (0, 2.2 and 10°) into account. Within CEPT, sharing studies have been conducted for each combination of elevation/gain and statistical aspects are taken in consideration only in a second step when analysing the results.

Moreover, as far as antenna gain and elevation statistics are concerned, CEPT believes that statistics should be made in terms of links and not in terms of receivers. Indeed, if one FS receiver is interfered, the whole link is affected.

1.6 FS feeder loss

The current value used for feeder loss in sharing studies is 3dB. However, it was remarked by some CEPT countries that their FS networks have in average smaller feeder loss values.

1.7 Location and size of geographical distribution of FS receivers for the purpose of interference calculation

The difference in the results of sharing studies (some studies within ITU showing that the PFD limits are adequate to protect the FS, other studies showing that they are not) are often due to differences in the location and size of the area where FS are distributed.

Specifically, there are large critical areas on the surface of the Earth, where the elevation angle to an active HIO satellites is low, in which the long term protection criterion for FS receivers can be exceeded for an FS azimuth range of several degrees (the range value depending on the FS elevation angle and antenna gain). Given the HIO orbital characteristics, the determination of such areas is straightforward: These areas are bands of several degrees in latitude that approximately follows the visibility contour line of the satellite, when at its apogee, potentially around the entire globe. The location of the area where interference is computed with respect to these critical areas, is fundamental in terms of the resulting probability.

Furthermore, when the evaluation of interference is done in a statistical way, the size of the geographical area, over which the probability of exceeding the protection criteria is computed,

greatly influences the results. As FS receivers are planned at country level and not on a global scale, it is important that the area over which statistical considerations are performed reflects this aspect. Probabilities of excessive interference computed over the entire surface of the globe, one hemisphere, or on large geographical areas spanning over multiple countries does not reflect the actual probability for an FS operator in one specific country to experience excessive interference in existing or planned FS links.

1.8 FS protection criteria

It has been noted that the criteria of Recommendation ITU-R F.1495 have been derived so that, with the assumptions used in the derivation, the performance objectives of the FS are met.

It is agreed that the three interference criteria in the *recommends* of Recommendation ITU-R F.1495 should be used for the studies. There was no agreement within ITU-R WP4-9S to apply the long term criteria contained in Section 4 of Annex 1 of Recommendation ITU-R F.1495. With this criteria, the impact on the FS would have been increased and consequently the limitations imposed on the FSS would have been stronger.

It should be noted that, in the studies leading to the proposal of a new pfd mask, some slight excess of the ITU-R F.1495 was considered as acceptable (i.e. the thresholds are exceeded for a small percentage of azimuth)

1.9 ATPC

ATPC for the FS was not taken into account in the sharing studies. If this parameter would have been used, the impact on the FS would be increased and consequently the limitations imposed on the FSS would be stronger.

1.10 Ways of taking the satellites into account

WP4A suggested that the maximum number of co-frequency, co-coverage satellite systems to be used in the study is three. Simulations have shown that studies taking into account all satellites both active and visible per system or studies taking into account one satellite per system (for example the satellite creating the highest level of interference at the FS station) give similar results due to the FS antenna discrimination.

1.11 Summary of the differences in used methodologies and discrepancies between results

In summary, studies which show small or zero excess of the protection criteria, use some of the following interference mitigating factors which explain for the difference in their conclusions:

1) The current pfd mask is not used. Only very narrow spot beams are considered for testing the suitability of the pfd mask, while proposed or future HIO systems may use larger beams (see Sec.1.2).
2) Some studies are based on the use of Rec. ITU-R SF.1602, which is considered inappropriate by CEPT for studies under Agenda Item 1.18 for a number of reasons (see Sec. 1.3).
3) As far as gas absorption is concerned, Rec. ITU-R SF.1395 is not taken into account. According to this WP 4-9S recommendation, for the purpose of frequency sharing studies, it is necessary to consider, for a given latitude range, the minimum seasonal gaseous attenuation to interference to guarantee protection all year round. Also, in some of the studies, gas absorption in tropical regions is considered, which introduces a significant attenuation and is not representative of the majority of the globe.

4) All or part of the area where interference is computed is outside the critical areas where excessive interference can actually occur (see Sec.1.7).

Furthermore, there is a number of additional factors that, if taken into account, could still increase the amount of excessive interference to the FS (see Sec. 1.6, 1.8, 1.9 above).

2. Additional consideration on some satellite systems for which there may be no need of tightening the mask

Of the three non-GSO FSS HIO systems currently filed with the ITU, system USCSID-P is the only one not likely to cause interference in excess of the FS protection criteria, even if operating at the current pfd limits, because of its particular orbital and operational characteristics. In fact, the orbital characteristics are such to create eight repetitive earth tracks of the Molniya type, equally spaced in longitude with only one satellite describing each of them. As a consequence, the portion of the sky corresponding to the apogee is not constantly occupied by a one satellite, as, when one satellite moves away, there is no other satellite to replace it. Instead, the link has to be switched to a satellite in one of the adjacent tracks with a significantly different azimuth and elevation angle, so that, in terms of impact on the FS, the FS antenna angular discrimination would reduce the amount of received interference. In summary, a satellite in a satellite system with only one satellite per each repetitive earth track is not likely to stay in the main beam of an FS receiver long enough to cause exceedance of the protection criteria.

3. Methods to satisfy the agenda item and impact on HIO FSS systems

New pfd masks have been studied for HIO systems having the characteristics of HIO systems already existing or filed within ITU. Some studies have also been conducted to assess the impact of these masks on HIO FSS systems.

After the WP4-9S meeting in August 2006, two possible new pfd masks were proposed: -123/-110 dB(W/m²/MHz) supported amongst others by CEPT and -125/-105 dB(W/m²/MHz) supported by Korea. This second Mask for Method C has been suppressed by the CPM07-2 meeting, following a Korean contribution. Therefore, there is only one mask remaining for this Method (-123/-110 dBW/m²) which is supported by CEPT.

It should be noted that, with this mask, there may be, in some cases, interference to the FS in excess of the protection criteria given in Recommendation ITU-R F.1495. Considering that more stringent pfd masks would put some significant constraints on the FSS, this proposed new mask is seen as an acceptable solution.

CEPT is of the view that a tightening of the pfd mask for FSS (method C of the CPM Report) with the proposed mask above is a good approach to satisfy the agenda item.

However, some additional consideration needs to be given on the impact of the tightening of the pfd mask on FSS:

- It is noted that N-SAT-HEO2 has already been filed with this tighter mask.
- As pointed out in section 2, the tightening of the mask may not be needed for HIO FSS satellite system (USCSID-P), while it will create some unnecessary constraints to this FSS system. Therefore, it may be envisaged to explore some ways to exclude FSS systems with the same orbital and operational characteristics from the tightening of the pfd mask.
- Studies within CEPT show that there is a need to tighten the pfd mask for FSS system USAVKA-H1 to protect the FS. In practice this means that the pfd mask -123/-110

dB(W/m²/MHz) can be accommodated by increasing the minimum transmit boresight elevation angle to ~25°, taking into account the roll-off factor based on the parameters in Table 3 of Doc.4-9S 166, Annex 4. After appropriate consideration and studies, CEPT is of the opinion that such limits will not unduly constraint this type of FSS system. It was noted that the goal of such a type of HIO system, wanting to achieve almost global coverage with only three HIO satellites by using a minimum elevation angle of 10°, is already a difficult design objective.

- Measures such as downlink power control, already implemented on USCSID-P system, will help overcome the difference in satellite pfd in different portions of the orbit and, therefore, help complying with a tighter pfd mask. Future advances in technology are likely to facilitate the use of such measures.
- Future satellite systems will be designed to cope with the tighter pfd mask.

On the basis of the previous considerations, it is considered that a possible alternative solution to a tighter pfd mask may be to mandate appropriate limitations on the satellite antenna roll-off characteristics, minimum satellite transmit boresight angle and antenna beamwidth that would achieve the same objectives in term of protection of the FS (method B of the CPM Report). This requires further technical work for the selection of the appropriate limitations and the practical implementation of this method.

4. Mitigation techniques

The following methods have been studied as potential mitigation techniques to be applied to FS:

a) change in orientation of the path;

b) attenuate the signal at the receiver and increase the transmitted power by a corresponding amount;

c) change the gain of the FS antenna;

d) consider site shielding;

e) for high elevation angle paths, use a lower FS gain antenna;

f) minimize the elevation angle of the FS antenna.

It is agreed that no currently proposed mitigation techniques could be applied to existing links. Therefore, CEPT believes that these mitigation techniques can not be considered when deriving pfd limits for Agenda Item 1.18.

5. List of relevant documents

Recommendation ITU-R F.1495 “Interference criteria to protect the fixed service from time varying aggregate interference from other services sharing the 17.7-19.3 GHz band on a co-primary basis”.

Recommendation ITU-R P.676 “Attenuation by atmospheric gases”.

Recommendation ITU-R SF.1395 “Minimum propagation attenuation due to atmospheric gases for use in frequency sharing studies between the fixed-satellite service and the fixed service”.

Recommendation ITU-R S.672 “Satellite antenna radiation pattern for use as a design objective in the fixed-satellite service employing geostationary satellites.”

CPG PT3 Documents (04)27, 28 and 35.

ITU-R Document 4-9S/166 Annex 9 (Chairman’s report of the August 2006 4-9S meeting)

[CPM Report to WRC-07 on agenda Item 1.18.]

6. Actions to be taken

Further consider the impact on the FS of possible restrictions of FSS operational characteristics, such as satellite transmit boresight elevation angle, satellite antenna roll-off characteristics and beamwidth and the practical implementation of such limitations.

Further consider the possibility of a regulatory filter that may exclude some types of satellite systems from the need of tightening the pfd mask based on orbital and operational characteristics.

Consider the most appropriate way to address the '*instructs the Radiocommunications Bureau'* of Resolution 141.

Further develop CEPT views if required.

7. Proposals from outside CEPT

Regional telecommunication organisations

APT (January 2007)

APT Preliminary views

APT members support the study results conducted by ITU-R to review the current PFD limits for satellite systems using highly inclined orbits (HIOs) to adequately protect the fixed service without unduly constraining these satellite systems in the band 17.7 – 19.7 GHz.

Satellite systems using HIOs should continue to be considered as a subset of non-GSO systems and have the same regulatory procedure as other types of non-GSOs. There is no need to modify the Radio Regulations in the above respect.

Most APT members are of the view that the current pfd limits in Article 21 of the Radio Regulations are not appropriate to ensure the protection of FS systems from HIO FSS systems.

Most APT members support Method C while some other APT members support Method B under section 4/1.18/3 of the draft CPM Report as a response to satisfy this agenda item.

The APT members supporting Method C are encouraged to consider the two proposed pfd masks in Method C with the view to making a decision on one appropriate pfd mask at the next meeting (see Annex 1 to this document for detailed information).

Should there be any need for a definition and/or description of HIO this text may be included in an ITU-R Recommendation. However, it should not be included in the Radio Regulations.

CITEL (October 2006)

Canada, United States

1. Canada and the United States support no change to the pfd limits in Table **21-4**, Article **21.** The current pfd limits are adequate to protect the terrestrial services from non-GSO FSS satellites in highly-inclined elliptical orbits operating in the 17.7-19.3 GHz band.

2. Agenda Item 1.18 and its associated resolution, although ambiguously worded so as to encompass some circular-orbit non-GSO systems that meet the apogee altitude and orbital inclination criteria in *considering g)* of Resolution **141 (WRC-03)**, was intended to apply to highly-inclined (i.e., between 35º and 145º) non-circular-orbit non-GSO FSS satellite systems with orbital apogee altitudes greater than 18,000 km and orbital perigee altitudes that are less than the orbital apogee altitudes. Consequently, there is no need to review the limits that apply to those non-GSO satellite systems using circular orbits, such as medium earth orbits (MEO) that satisfy both the apogee altitude criterion and the inclination criterion.

3. Canada and United States support the ongoing studies within the ITU-R on sharing between non-GSO systems in the 17.7-19.7 GHz band using HIOs and FS networks in the same band, in particular, the use of realistic assumptions both for the relevant characteristics of the fixed-satellite service – including the number of active HEO/HIO satellites in view of a particular fixed service station – and for the relevant characteristics of fixed service systems.

4. Satellite networks using HIOs should continue to be considered as non-GSOs and have the same regulatory standing as other types of non-GSOs such as those in low and medium earth orbits. There is no need to modify the Radio Regulations in a way that categorizes HIO non-GSO operations separately from other non-GSO systems.

5. Canada and United States of America accept the guidance provided to WP 4-9S by WP 4A on the nature of specific operational characteristics and parameters of FSS HEO systems and recognizes this guidance as a fundamental element in the modeling of interference from HIO systems into FS networks.

6. In light of the progress made on this issue in WP-4-9s and WP-4A, the United States is in favour of suppression of Resolution **141** (WRC-03).

RCC (September 2006)

Under this agenda item the satellite systems using both elliptical and circular orbits with the apogee altitude greater than 18 000 km and an orbital inclination between 35° and 145° should be considered.

Decision on the PFD limitation should ensure protection to the fixed service stations without insubstantial constraints to the FSS.

This decision should be based not only on the worst cases examination, but also on the statistical estimation of the interference probability exceeding the authorized limits.

Taking into account the results of studies based on the mask of the PFD determining the possibility of maximum interference caused by the non-GSO (HEO) satellites the RCC Administrations consider that the power flux-density limits prescribed by RR in the band concerned should not be more stringent.

[Editor's note: the RCC position is expected to be clarified at the April 2007 RCC meeting.]

SFCG (October 2006)

SFCG supports the protection of existing science services allocations. Potential modifications to the pfd limits should not be permitted to have an adverse impact on the extension of the MetSat allocation in the range 18.0 to 18.4 GHz. WRC decisions should not relax the pfd limits that protect the passive service allocation in 18.6-18.8 GHz. SFCG members are encouraged to take an active role in the development of proposals and positions within their respective Administrations' preparatory processes for the CPM and WRC-07.

Eumetnet/WMO (February 2007)

The protection of the 18.6-18.8 GHz EESS (passive) band from FSS and FS are given in RR provisions **5.522A**, **21.5A**, **21.16.1** and **5.522B**.

In addition, the extension from 200 to 300 MHz bandwidth of current METSAT allocation is currently under study in the 18.0-18.4 GHz under agenda item 1.2 (WRC-07).

EUMETNET/WMO is of the view that the determination of power flux density (pfd) limits to be applied to Highly Elliptical Orbit (HEO) satellites in the 17.7-19.7 GHz band shall not lead to any review of the abovementioned RR provisions and shall also not impede the possible METSAT allocation in the 18 GHz range.