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Draft US Proposal on WRC-03 Agenda Item 1.24

Agenda Item 1.24: "to review the usage of the band 13.75 - 14.0 GHz, in accordance with Resolution **733 (WRC-2000)**, with a view to addressing sharing conditions"

Background information

Prior to WRC-2000, footnote **S5.502** contained constraints such as e.i.r.p. and antenna size limits on fixed-satellite service earth stations and e.i.r.p. limits on the radiolocation service. Footnote **S5.503** contained e.i.r.p. limits on the fixed-satellite service to protect the space research service. These constraints were intended to accommodate a delicate sharing of the band among these services. These constraints were developed based upon agreements reached at WARC-92 and applied to subsequent sharing studies on the planned use of 13.75-14.0 GHz by geostationary satellites in the FSS, and were intended to limit the number of FSS earth stations to the point that sharing could occur, though a potential for interference from the limited number of earth stations would still exist. Since the time that the regulatory constraints were developed, GSO FSS operators have expressed interest in operating small earth stations. This is due to the increased requirement for broadband data services delivered to businesses, hospitals, schools, etc., in both rural and urban areas. Radiolocation operators have expressed interest in using higher than currently allowed e.i.r.p. values. WRC-2000 modified footnotes **S5.502** and **S5.503** to include:

- within footnote S5.502 that the protection of the receiving space stations in the FSS operating with earth stations that, individually, have an e.i.r.p. of less than 68 dBW shall not impose constraints on the operation of the radiolocation and radionavigation stations operating in accordance with the Radio Regulations.
- within footnote S5.503 that the e.i.r.p. density of emissions from any earth station in the FSS operating with a space station in the geostationary satellite orbit shall not exceed 71 dBW in the band 13.772 to 13.778 GHz until those geostationary space stations in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 cease to operate in this band; that the e.i.r.p. density of emissions from any earth station in the FSS operating with a space station in non-geostationary satellite orbit shall not exceed 51 dBW in the band 13.772 to 13.778 GHz until those geostationary space stations in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 cease to operate in this band.

Resolution **733 (WRC-2000)** invites the ITU-R "to conduct studies, as a matter of urgency and in time for consideration by WRC-03, on the sharing conditions indicated in Nos. **5.502** and **5.503**, with a view to reviewing the constraints in No. **5.502** regarding the minimum antenna diameter of GSO FSS earth stations and the constraints on the e.i.r.p of the radiolocation service

and to identify and study, in time for consideration by WRC-03, possible alternative sharing conditions to those indicated in Nos. **5.502** and **5.503**."
A joint decision of Study Groups 4, 7 and 8 (Document CVC-11/9, dated 8 June 2000) established Joint Task Group 4-7-8 to carry out the studies under Resolution **733** on the sharing conditions in footnotes **S5.502** and **S5.503** with a view to review the minimum antenna diameter of GSO FSS Earth station's and the e.i.r.p. constraints of the radiolocation service.

Within this Joint Task Group, studies have been carried out to determine the constraints that would enable fixed-satellite service earth stations with antenna diameters less than 4.5 meters to share with the shipborne radars. The studies have shown that locating fixed-satellite service earth stations a certain distance in-land will greatly minimize the interference into shipborne radars. These studies have also determined a power flux-density level produced by an earth station at a certain location will protect shipborne and land radars. A study determined the levels of off -axis e.i.r.p. density that will protect airborne radars. With respect to sharing between FSS earth stations and space research service systems, the studies have identified maximum on-axis e.i.r.p. density levels that will protect the space research service systems. All of these constraints will enable fixed-satellite service earth stations to share with shipborne, airborne and land-based radars and space research service systems while allowing the FSS to deploy antennas with diameters smaller than 4.5 meters. As such, it is appropriate to modify footnote **5.502** to remove the antenna diameter limitation and specify the constraints on the fixed-satellite service. These studies have led to Option A below.

It is noted that the radiolocation allocation in the band 13.75 - 14.0 GHz is part of a larger allocation that spans from 13.4 - 14.0 GHz. Several input documents into the JTG are based on the scenario where there are six ships operating in the same general area. Each ship is equipped with two radar systems, and each system operates over a 10 MHz bandwidth, resulting in a total occupied bandwidth of 120 MHz. This information has led to Option B below.

Proposals:

OPTION A:

USA/1.24/A1

MOD 5.502

5.502 In the band 13.75-14 GHz, an earth station of a non-geostationary ~~in the~~ fixed-satellite service network shall have a minimum antenna diameter of 4.5 m ~~and the e.i.r.p. of any emission should be at least 68 dBW and should not exceed 85 dBW~~. In addition the e.i.r.p., averaged over one second, radiated by a station in the radiolocation or radionavigation services shall not exceed 59 dBW above 2° elevation and 65 dBW below. ~~The protection of assignments to receiving space stations in the fixed-satellite service operating with earth stations that, individually, have an e.i.r.p. of less than 68 dBW shall not impose constraints on the operation of the radiolocation and radionavigation stations operating in accordance with the Radio Regulations. No. 5.43A does not apply. See Resolution 733 (WRC-2000).~~ An administration planning to use FSS earth stations less than 4.5m in a geostationary network in this band shall ensure that the single entry power flux density produced by any earth station operating within its territory does not exceed

- 114.7 dBW/m^2/10 MHz not to be exceeded for more than 0.1% of the time produced at 36 m above sea level at the baseline (low water mark as defined in UN Convention on Law of the Sea 1982).
- 114.7 dBW/m^2/10 MHz not to be exceeded for more than 0.1% of the time produced 3 m above ground at the border.-

These limits do not apply to FSS earth stations brought in service prior to 4 July 2003. The power flux-density produced by an FSS earth station shall be calculated in accordance with Resolution **ZZZ.**

Reason: This modification to the footnote will allow for the operation of FSS earth stations with antenna diameters smaller than 4.5 meters while protecting shipborne and land-mobile radar systems. Resolution ZZZ will provide a methodology for Administrations to calculate the power flux-density levels from a given FSS earth station and will also address additional mitigation techniques that may be necessary for FSS earth stations located close to either the baseline or a border.

USA/1.24/A2

MOD 5.503: In the band 13.75 - 14 GHz, geostationary space stations in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 shall operate on an equal basis with stations in the fixed-satellite service; after that date, new geostationary space stations in the space research service will operate on a secondary basis. Until those geostationary space station in the space research service for which information for advance publication has been received by the Bureau prior to 31 January 1992 cease to operate in this band:

- the e.i.r.p. density of emissions from any earth station in the fixed-satellite service operating with a space station in geostationary-satellite orbit shall comply with Section VII of Article 22 ~~not exceed 71 dBW~~ in the 6 MHz band from 13.772 - 13.778 GHz;
- the e.i.r.p. density of emissions from any earth station in the fixed-satellite service operating with a space station in non-geostationary-satellite orbit shall not exceed 51 dBW in the 6 MHz band from 13.772 - 13.778 GHz.

Reason: This modification provides a satisfactory solution to the sharing situation between the fixed-satellite service and the space research service in the band 13.772 - 13.778 GHz. This will allow for the use of smaller antenna diameter earth stations in the fixed-satellite service without impacting the space research service operations. Since the studies have shown that the on-axis e.i.r.p. density limitations vary for different antenna sizes, it is best to put the new limits in a new section of Article 22. An alternative approach, where the limits are defined as an equation based on antenna diameter, is to add the equation to the footnote.

USA/1.24/A3

ADD Section VII of Article 22

Section VII - EIRP density limitations on earth stations in the fixed-satellite service operating in the band 13.772 - 13.778 GHz

22.40 The level of equivalent isotropic radiated power (e.i.r.p) emitted by an earth station of a geostationary-satellite network in the fixed-satellite service operating in the band 13.772 - 13.778 GHz shall not exceed the following values for the given antenna size:

Antenna diameter	Maximum e.i.r.p density
0.75 m	-11.2 dB(W/Hz)
1.2 m	-7.1 dB(W/Hz)
1.8 m	-3.6 dB(W/Hz)
2.4 m	-1.1 dB(W/Hz)
≥ 4.5 m	4.4 dB(W/Hz)

USA/1.24/A4

ADD 21.13*bis*

21.13*bis* The level of equivalent isotropically radiated power (e.i.r.p.) emitted by an earth station of a geostationary-satellite network in the frequency band 13.75 - 14.0 GHz shall not exceed the following values for any off-axis angle φ which is 2° or more off the main-lobe axis of an earth station:

Off-axis angle	*Maximum e.i.r.p. in any 1 MHz band*
$2° \leq \varphi \leq 7°$	43 - 25 log(φ) dBW
$7° < \varphi \leq 9.2°$	22 dBW
$9.2° < \varphi \leq 48°$	46 - 25 log(φ) dBW
$48° < \varphi \leq 70°$	4 dBW
$70° < \varphi \leq 180°$	14 dBW

These e.i.r.p. limits do not apply to FSS earth station antennas brought in service prior to 4 July 2003, nor to earth stations associated with a satellite network in the fixed-satellite service for which complete coordination or notification information has been received before 4 July 2003.

Reason: This modification will allow for the operation of FSS earth stations with antenna diameters smaller than 4.5 meters while protecting airborne radar systems.

USA/1.24/A5

ADD Resolution ZZZ

Resolution ZZZ

Methodology for calculating the power flux-density at Radiolocation stations located at the baseline[1] or at the border of an Administration produced by GSO FSS Earth stations in the 13.75-14 GHz band

The World Radiocommunication Conference (Geneva, 2003),

considering

a) that WARC-92 (Malaga-Torremolinos, 1992) added a primary allocation to the fixed-satellite service (Earth-to-space) in the 13.75 - 14.0 GHz band;

b) that this band is also allocated on a primary basis to the radiolocation service;

c) that, in some countries, the band is also allocated to the fixed service, the mobile service (Nos. 5499 and 5.500) and the radionavigation service (No. 5.501);

d) that Resolution 733 of WRC-2000 invited the ITU-R to conduct studies, as a matter of urgency, on the sharing constraints indicated in Nos. 5.502 and 5.503, with a view to review the constraints in No. 5.502;

e) that No. 5.502 was modified to allow GSO fixed-satellite service systems to operate earth station antennas with no limit on the antenna in the band 13.75 - 14.0 GHz subject only to a power flux density limit at 36m above sea level at the baseline (low water mark as defined in UN Convention on Law of the Sea 1982) of -114.7 dBW/m2/10MHz for 0.1 % of the time or a power flux density limit at 3 m above ground level at the border of another administration of -114.7 dBW/m^2/10 MHz not to be exceeded for more than 0.1% of the time;

f) that GSO fixed-satellite service earth stations operating in the band 13.75 - 14.0 GHz may need to employ certain mitigation techniques in order to reduce the interference into the radiolocation systems when they are located in close proximity to the baseline or the border of another Administration;

g) that there may be several mitigation techniques available to the GSO fixed-satellite service earth stations referred to in *considering f)*, including natural and man-made site shielding, minimum elevation angle, etc, that will offer significant signal discrimination,

[1] low water mark as defined by UN Convention on Law of the Sea 1982

resolves

1 that administrations use the methodology in Annex 1 to calculate the power flux density level at 36m above sea level at the baseline (low water mark as defined in UN Convention on Law of the Sea 1982) or at 3 m above ground level at the border of another administration from a GSO FSS earth station operating in the 13.75-14 GHz band

invites ITU-R

to study, as a matter of urgency, additional technical and procedural measures (e.g., natural and man-made site shielding) which GSO fixed-satellite service earth stations operating in the frequency band 13.75 - 14.0 GHz, should take to ensure the power flux density limit in considering d) is met.

ANNEX 1

Method for calculating the power flux-density at Radiolocation stations located at the baseline[2] or at the border of an Administration produced by GSO FSS Earth stations in the 13.75-14 GHz band

1 General

1.1 This Annex describes a method of calculating the interference potential from GSO FSS earth station transmitters to Maritime or land-based mobile radiolocation receivers.

1.2 This method is in two parts:

a) the calculation of the likely power flux-density produced at any point 36m above sea level at the baseline or at any point 3 m above ground level at the border of another administration;
b) The calculation of the likely power flux-density produced at any point 36m above sea level at the baseline or at any point 3 m above ground level at the border of another administration taking into account the site shielding and other mitigation techniques

1.3 The interference potential of a GSO FSS earth station transmitter must be considered case by case; the power flux-density produced by each GSO FSS earth station transmitter into a maritime radiolocation receiver at a point 36m above the baseline or into a land-based mobile radiolocation receiver at a point 3m above ground level at the border of another administration shall be less than the interference power flux-density limit.

[2] low water mark as defined by UN Convention on Law of the Sea 1982

1.4 It is emphasized that, should the calculation described in this Annex indicate that the maximum permissible power flux-density is exceeded, it does not necessarily preclude the introduction of an FSS earth station since the calculations are based on specific assumptions for:

a) the nature of the terrain of the interference path;

b) the off-beam discrimination on the radiolocation receiving installations;

c) the necessary protection ratios for the radiolocation service;

d) the type of maritime radiolocation service that will be deployed in that area;

e) the value of power flux-density to be protected in the radiolocation service;

f) the specific propagation conditions between the GSO FSS earth station and the radiolocation receiver.

2 Limit of power flux-density

General

The interference power flux-density from a GSO FSS earth station transmitter into a radiolocation receiver at 36m above the baseline or at 3m above ground level at the border of another administration shall not exceed the following:

$$X \text{ dBW/m}^2\text{/10MHz for more than } Y \text{ \% of the time} \quad (1)$$

where:

X: the maximum permissible interfering power flux-density (dB(W/m^2)) within the 10 MHz bandwidth of the radiolocation receiver;

Y: the percentage of time the GSO FSS earth station interfering power flux-density, X, would be seen by the radiolocation receiver;

2.2 Single entry Power Flux Density Level

2.2.1 The single entry power flux density level to protect for the Radiolocation receiver is based on an I/N requirement of –6dB which corresponds to an interference level of –133 dBW in a bandwidth of 10 MHz at the receive output flange of a radiolocation antenna.

2.2.2 A signal from a GSO FSS earth station should be considered only if its necessary bandwidth overlaps the 13.75-14 GHz band.

2.2.3 The pfd level at the radiolocation antenna which would correspond to the –133 dBW /10MHz to the receiver can be derived as follows:

Since the gain of the radiolocation toward the horizon is 26 dBi, its effective aperture calculated from equation (4) is:

$$A_e \text{ dBm}^2 = 26 \text{ dBi} + (-44.3 \text{ dBm}^2) = -18.3 \text{ dBm}^2. \quad (2)$$

Thus, at the point in its scan where the radiolocation antenna is pointed at the FSS ES, the received interfering signal power at the output of the antenna is:

$$\text{If } I = -133 \text{ dBW/10MHz}$$

$$I = pfd + Ae = -133 \text{ dBW/10MHz} - (-18.3 \text{ dBm}^2)$$

$$pfd = -114.7 \text{ dBW/m}^2\text{/10MHz}. \quad (3)$$

A pfd of –114.7 dBW/ m^2/10MHz at the face of the antenna would just meet the –6 dB I/N threshold whenever the radiolocation antenna is pointed directly at the FSS ES.

2.3 Probability of Interference

2.3.1 The probability that the radiolocation receiver would receive interference from a GSO FSS earth station would depend upon the radiolocation antenna beamwidth and the rotation/scan angle, and the variation of the propagation loss as a function of time.

2.3.2 The duty factor of an individual FSS earth station should also be taken into account in the calculation of the percentage of time that the power flux-density is received at the radiolocation receiver.

2.3.3 The combined probability of interference into the main beam of the radiolocation antenna and the interference path propagation loss should be equivalent to 0.1 % of the time.

2.4 Radiolocation Antenna Pattern

2.4.1 The azimuthal angular discrimination of the radiolocation antenna is shown in Figure 1 and the parameters for the radiolocation antenna are given in Table 1.

Figure 1. Radar Antenna Gain Pattern as a Function of Azimuth Off-Axis Angle

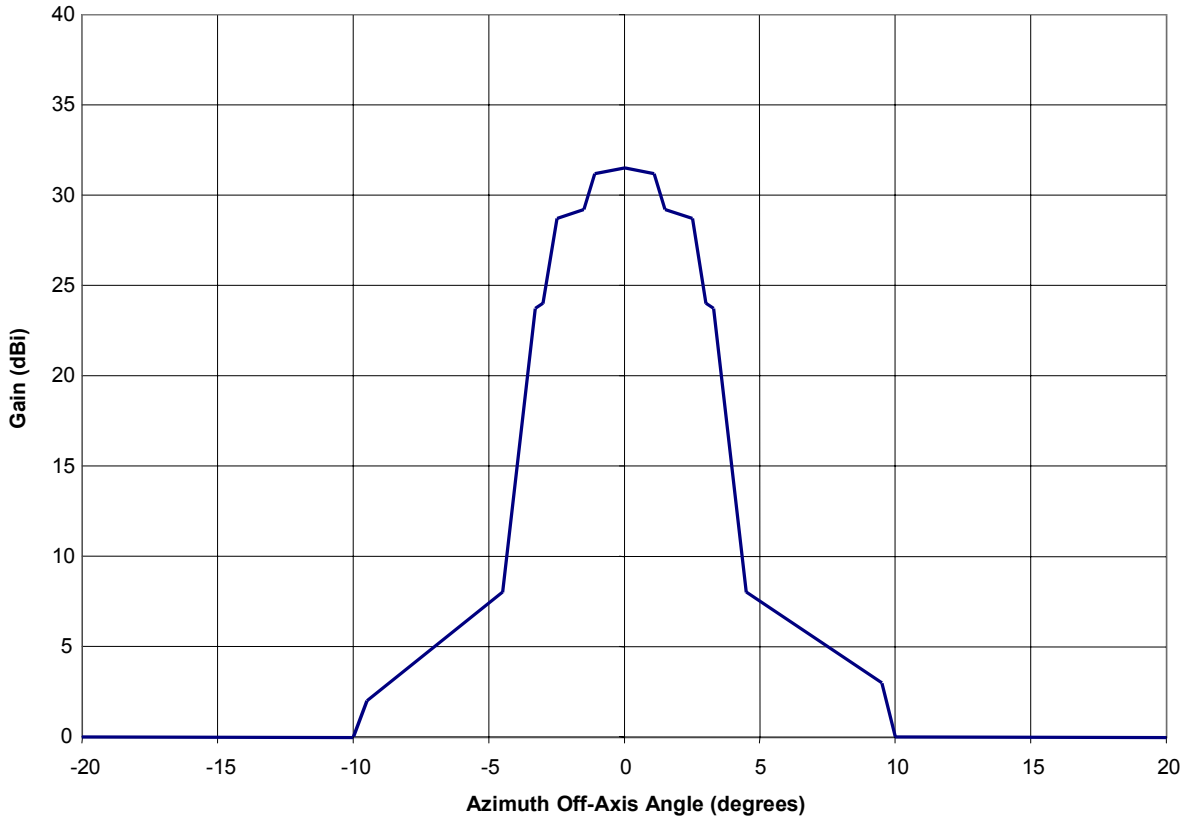

Table 1. Radar Antenna Parameters

Elevation beamwidth (degrees)	Elevation beam centre (degrees)	Maximum Gain (dB)	Azimuth beamwidth (degrees)
10	4.5	31.5	2.2

2.4.2 For this antenna operating at an elevation angle of 4.5 degrees the antenna gain in the direction of the horizon would be approximately 26 dBi.

3 Power flux-density produced by a GSO FSS Earth station (F_p)

The power flux-density F_p (dB(W/m^2-10MHz)) produced at any point on the baseline or the border where a radiolocation station could be located is determined from the following formula:

$$F_p = P_i + G_\phi - A + 44.3 \quad (4)$$

where:

P_i: the input power (dBW/10MHz) into the FSS earth station antenna;

G_ϕ : the gain (dBi) of the GSO FSS earth station in the direction of the radiolocation station, taking into account the elevation and azimuth angle discrimination;

A: the total path loss (dB).

3.1 Evaluation of path loss *A* for a GSO FSS earth station at a distance greater than 100 km from baseline or the border of another administration

For path lengths greater than 100 km, A is given by:

A = path loss to be calculated by relevant ITU-R Recommendations (Rec ITU-R P.452-10 and Rec. ITU-R P.526)[3] (5)

3.2 Evaluation of path loss *A* for a GSO FSS earth station at a distance equal to or less than 100 km from the baseline or the border of another administration

For path lengths equal to or less than 100 km, A is calculated using equations (6) and the value obtained is substituted in formula (4) to calculate the power flux-density produced at the point concerned on the edge of the service area:

A = path loss to be calculated by relevant ITU-R Recommendations (Rec ITU-R P.452-10 and Rec. ITU-R P.526)[3] (6)

[3] Another method to calculate the path loss may be developed by the Joint Correspondence Group of Joint Task Group 4-7-8

3.3 Calculation of the percentage of time factors due to the rotation of the radar and the duty factor of the GSO FSS earth station

Although the power flux-density level calculated in the above sections corresponds to the level that would be received by the radiolocation receiver at all times when the GSO FSS earth station is transmitting, this level corresponds to an I/N of -6 dB only when the interference is received by the radiolocation system with its antenna directed at the FSS earth station. Therefore, for times when the azimuth mainbeam of the radiolocation antenna is not directed toward the GSO FSS earth station, the interference received will result in an I/N that is less than -6 dB and the radar will be sufficiently protected. This important factor needs to be included in the determination of the percentage of time that a power flux-density level may be exceeded. In order to determine the percentage of time that the radiolocation receiver would experience an I/N of -6 dB, the rotation of the radar needs to be taken into account. As an example, consider the antenna shown in Section 2.4. This antenna has an azimuth 3 dB beamwidth of 4.4° (2.2° on each side of the mainbeam). If we assume that this antenna rotates 360° in azimuth, the percentage of time the power flux-density level calculated above will result in an I/N of -6 dB is 1.22%. For the rest of the time, the I/N resulting from this power flux-density level will be less than -6 dB. This calculation overestimates the percentage of time that the radar will be affected because the power flux-density at 2.2° off the mainbeam is already 3 dB below the maximum antenna gain.

Additionally, in determining the percentage of time the calculated power flux-density level will be received, the duty factor of the individual GSO FSS earth station needs to be taken into account. Following on the above example, if the duty factor for the GSO FSS earth station is 10%, the resultant percentage of time that the power flux-density level will be received is 1.22% x 10%, or 0.12%.

3.4 Distance beyond which the method need not be applied

The method need not be applied when the distance between the GSO FSS earth station and the baseline or the border of another administration is greater than:

a) 100 km in the case of all overland paths; *or*

b) 125 km in the case of all oversea or mixed paths[4].

4 Site Shielding and Other Mitigation Techniques

In the case that the calculation of the power flux-density level and percentage of time in Section 3 results in a level that exceeds the interference threshold for the radiolocation system, other mitigation techniques, such as site shielding, may be used at the GSO FSS earth station in order to reduce the power flux-density to a level that meets the threshold. Further study is necessary to determine the additional signal discrimination from both natural and man-made site shielding.

[4] The Joint Correspondence Group of Joint Task Group 4-7-8 may develop numbers different than these in the course of its work.

Reason:

This resolution is necessary to define a calculation methodology to be used by Administrations when FSS earth stations are deployed in the frequency band 13.75 - 14.0 GHz.

USA/1.24/A6

SUP Resolution 733

Reason: As the above proposals satisfy the agenda item and the Resolution, Resolution 733 is no longer needed.

OPTION B:

USA/1.24/B1

MOD 5.502 In the band 13.75 - 13.875~~-14 GHz~~, an earth station in the fixed-satellite service shall have a minimum antenna diameter of 4.5 m and the e.i.r.p. of any emission should be at least 68 dBW and should not exceed 85 dBW. In the band 13.875 - 14 GHz, an earth station of a non-geostationary fixed-satellite service network shall have a minimum antenna diameter of 4.5 m. In addition the e.i.r.p., averaged over one second, radiated by a station in the radiolocation or radionavigation services in the band 13.75 - 14 GHz shall not exceed 59 dBW. The protection of assignments to receiving space stations in the fixed-satellite service operating with earth stations that, individually, have an e.i.r.p. of less than 68 dBW shall not impose constraints on the operation of the radiolocation and radionavigation stations operating in accordance with the Radio Regulations. No. 5.43A does not apply.~~ See Resolution 733 (WRC-2000).~~

Reason: This modification will result in the same level of protection for the radiolocation systems in 125 MHz of the spectrum as they receive today. It will also result in the same level of protection for the SRS systems. This allows for the operation of FSS earth terminals smaller than 4.5 meters in a portion of the band.

USA/1.24/B2

ADD 21.13bis

21.13*bis* The level of equivalent isotropically radiated power (e.i.r.p.) emitted by an earth station of a geostationary-satellite network in the frequency band 13.75 - 13.875 GHz shall not exceed the following values for any off-axis angle φ which is 2° or more off the main-lobe axis of an earth station:

Off-axis angle	*Maximum e.i.r.p. in any 1 MHz band*
$2° \leq \varphi \leq 7°$	43 - 25 log(φ) dBW
$7° < \varphi \leq 9.2°$	22 dBW
$9.2° < \varphi \leq 48°$	46 - 25 log(φ) dBW
$48° < \varphi \leq 70°$	4 dBW
$70° < \varphi \leq 180°$	14 dBW

These e.i.r.p. limits do not apply to FSS earth station antennas brought in service prior to 4 July 2003, nor to earth stations associated with a satellite network in the fixed-satellite service for which complete coordination or notification information has been received before 4 July 2003.

Reason: This modification will allow for the operation of FSS earth stations with antenna diameters smaller than 4.5 meters while protecting airborne radar systems in the band 13.75 - 13.875 GHz.

USA/1.24/B3

SUP Resolution 733

Reason: As the above proposal satisfies the agenda item and the Resolution, Resolution 733 is no longer needed.