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March 11, 2004

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BY HAND DELIVERY

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
Office of the Secretary
c/o Natek, Inc., Inc.
236 Massachusetts Avenue, N.E.
Suite 110
Washington, DC 20002

Re: Written *Ex Parte* Presentation
ARINC Inc. SKYLink Application, File No. SES-LIC-20030910-01261

Dear Ms. Dortch:

By its counsel, ARINC Inc. ("ARINC") hereby submits an original and two copies of a paper authored by Don Jansky of Jansky Barmat Telecomm, entitled "Assessment of Comments on the ARINC Proposed Mobile Satellite Service (AMSS) in the 14.0-14.5 GHz Band (SKYLINK)." In this paper, Mr. Jansky concludes that, contrary to the assertion of one commenter, no International Telecommunication Union ("ITU") Radio Regulation requires that access to the SKYLink System be accomplished only via positive control. He also determines that no ITU Radio Regulation requires ARINC to take antenna pointing error into account when it calculates aggregate off-axis e.i.r.p. and that there is no an ITU-R Recommendation that supports such a requirement.

Kindly direct any questions regarding this material to the undersigned.

Sincerely,

Carl R. Frank

Enclosure

cc(w/encl.): Karl Kensinger
Frank Peace
Arthur Lechtman

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Assessment of Comments on the ARINC Proposed Aeronautical Mobile Satellite Service (AMSS) In The 14.0-14.5 GHz Band (SKYLINK)

March 2004

Outline

1.0 Introduction

This report has been prepared to address technical/regulatory concerns which have been raised in proceedings before the FCC related to ARINC's application for authority to operate aboard aircraft up to 1,000 technically identical transmit and receive mobile earth stations (MES) in the 11.7-12.2 GHz (space-to-Aircraft) and 14.0-14.5 GHz (Aircraft-to-space) frequency bands. The proposed service is called SKYLink. These concerns involve:

a. Whether the texts from WRC-03 and CPM-02 related to WRC-03 Agenda Item 1.11[1] require use of positive control in the SKYLink system.

b. Whether Recommendation ITU-R M.1643 requires ARINC to take into account antenna pointing error in calculating aggregate off-axis interference.

These issues have been raised in comments made to the Commission in connection with the referenced SKYLink application.

The sections below will address these issues.

2.0 ITU-R Rules and Recommendations in Relation to Access Control

In comments on the ARINC SKYLink application it has been asserted "certain aspects of ARINC's proposal are inconsistent with the Commission's AMSS licensing precedent and Recommendation ITU-R M.1643." It appears that the "certain aspects" of concern are reflected in the statement: "The SKYLink system also does not satisfy the 'essential requirement' of positive control for Ku-band AMSS operations, a requirement that was discussed throughout the ITU-R study group process in developing Recommendation ITU-R M.1643."

Agenda Item 1.11 for WRC-03 was a derivative of actions taken at WRC-97. At that conference the secondary land mobile satellite allocation was changed to an allocation for "mobile satellite except aeronautical mobile satellite" in the band 14-14.5 GHz. Resolution 216, adopted at WRC-2000, indicated that the inclusion of the aeronautical mobile satellite service in this band was held in abeyance because of the uncertainties associated with the impact of transmissions from earth stations on board

[1] Agenda Item 1.11 required WRC-03 "to consider possible extension of the allocation to the mobile-satellite service (Earth-to-space) on a secondary basis in the band 14-14.5 GHz to permit operation of the aeronautical mobile-satellite service as stipulated in Resolution 216 (WRC-2000)."

aircraft, particularly with respect to being able to control emissions to avoid interfering with adjacent Ku-band satellites. At the initiative of the Boeing Company, Agenda Item 1.11 was adopted at WRC-2000, along with Resolution 216. Resolution 216 called for studies to determine the feasibility of sharing 14-14.5 GHz between a secondary AMSS and existing services in the band in time for WRC 03.

Subsequently the U.S. submitted and successfully defended contributions to ITU-R WP-4A /WP-8D, which "describe a methodology for how an AMSS system can operate and not cause harmful interference to GSO FSS systems. *See, e.g.*, 4A/28, 14 September 2000. These and other studies led to the successful adoption by ITU-R Study Group 8D of ITU-R Recommendation M.1643, entitled "Technical and operational requirements for aircraft earth stations of aeronautical mobile satellite service including those using fixed satellite service network transponders in the band 14-14.5 GHz (Earth-to-space)."

While achieving the passage of such a Recommendation was a great accomplishment it is important to note what the Recommendation is, and what it is not. First, it is not a regulation. The Recommendation itself indicates it is to be used for "technical guidance." This means that, at the international level, there is nothing mandatory about it. It is not part of a treaty. Further, while all or part of an ITU-R Recommendation may become mandatory if it is appropriately "included by reference in an ITU Radio Regulation," or if an ITU Administration like the United States chooses to make it mandatory for its own domestic purposes, that has not happened here with respect to the relevant parts of the Recommendation. As a general principle, the U.S. government has maintained a policy that ITU-R Recommendations are advisory in nature, offering only "guidance."

Second, it should not be considered unusual that the FCC licensing of the Connexion by Boeing system should make reference in its ordering clauses to language used in the US contribution to this Recommendation, as the development of this system was initially involved in the development and passage of this Recommendation. However, neither the basic provisions of that version or the adopted version of the Recommendation preclude system characteristics different than those of the Connexion System. For example, considering a) of the current Recommendation states "That

various technically and operationally different aeronautical mobile satellite service (AMSS) networks have been designed to commence operation in the near future."

Third, examination of the adopted Recommendation again indicates that it is to be used by administrations as guidance, and refers to Annex 1, Part A which is entitled "Essential requirements related to the protection of FSS networks." Of particular importance is Section 4 of Part A of this Annex. It states: "[the] AES (Aeronautical Earth Station) should be subject to the monitoring and control by an NCMC or equivalent facility." This is the only portion of the Recommendation which addresses a control requirement. There are no specifications as to what form such control should be, or what technique should be used.

Thus, contrary to comments made on the ARINC/SKYLink application, there does not appear to be any basis for stating that the SKYLink system's contention protocol scheme is not consistent with Recommendation ITU-R M.1643. Some comments have asserted that the terms "monitoring" and "control" denote "proactive and ongoing activity associated with positive control of AES transmitting in the 14-14.5 GHz." This seems to be an invention of the commenters. There is nothing in this Recommendation which specifies such a requirement. It may be a characteristic of, for example, the Connexion system. However, there is nothing in the referenced For Guidance Recommendation which requires such a control capability even were the Recommendation mandatory, which it is not.

It is understandable that such a design might be incorporated in the Connexion system, but it should also be pointed out that Section 4 of Part A of Annex 1 to Recommendation ITU-R M.1463 also uses the phrase "an equivalent facility." Thus, the Recommendation does not require the identical monitoring and control system as used by Connexion. SKYLink has its own Network Operations Center, and its contention protocol provides the necessary monitoring and control of the MES. Thus, there is no reason why the SKYLink system should not be considered an equivalent facility.

3.0 Requirements of ITU-R Decisions

3.1 CPM-02

Comments on the ARINC/SKYLink proposal have suggested that its proposed technique does not follow the requirements in the CPM 02 Report and WRC-03. This

section discusses the validity of such comments and whether they are relevant to the matter of licensing SKYLink to provide AMSS in the band 14-14.5 GHz as a secondary service.

The preface to the Conference Preparatory Meeting (CPM) Report for the 2003 World Radiocommunication Conference (WRC-03), notes that it was prepared "in response to Resolution 1156 of the ITU Council to assist those who will be involved in the preparations for and deliberations at WRC-03." The Report "represents the best information on technical, operational and regulatory/procedural issues relevant to the WRC-03 Agenda available at the time of its preparation and should provide a good basis for discussions at the Conference."[2] The CPM text addressing Agenda Item 1.11 is in Section 2.4 of the CPM Report. The full text of this Section is at Appendix B.

A principal conclusion of the CPM Report concerning the studies involving AMSS protection of the primary FSS allocation in the band, was:

> The studies show that an AMSS system operating on a secondary basis can compatibly operate with the FSS in the 14-14.5 GHz frequency band, provided aggregate co-frequency AES emissions in the direction of adjacent satellites are limited to levels that are equal to or less than the levels that have been accepted by other satellite networks. These conclusions apply equally to GSO and non-GSO FSS.[3]

The Report also concluded that "sharing is feasible between the secondary AMSS networks and the RAS in the 14-14.5 GHz," provided certain technical sharing conditions are satisfied.[4] In addition to the technical analyses section, there are also sections on methods to satisfy the agenda item, and regulatory and procedural considerations.

As the language from the Preface indicates, the CPM-02 Report was intended to provide information for the delegates to use at the WRC-03 as the majority of administrations attending WRC-03 did not participate in the development of the CPM text. (Note: The majority of countries attending WRC-03 did attend the CPM).

While the CPM report is considered to be one of the most, if not the most, important contribution to the work of the WRC-03, it is in no way obligatory or mandatory. There is no requirement to follow what may have been concluded in the

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[2] Preface, CPM Report-02, 2, *ibid.*
[3] Sec. 2.4.2.1.1, CPM-02.
[4] Sec. 2.4.2.2.1, CPM-02.

various sections of the CPM Report. In addition, there were five months between the completion of the report and the beginning of WRC-03 during which time a number of regional organizations such as CITEL, APT, the Arab League, and the CEPT had meetings to finalize their proposals to WRC-03. Indeed, a comparison of the Regional organization proposals to the conference, and the suggestions in the CPM report show that there are significant differences between what was agreed to at the CPM and what was being proposed at the Conference.

While the CPM-02 Report is important, it in no way mandates what the Conference should do on a particular agenda item. Indeed as discussed in the next section the WRC-03 Conference agreed to regulatory provisions different from those suggested in both Method A and Method B of the" Method to solve the agenda" section of the CPM Report for Agenda Item 1.11. Finally,, the CPM Report has no regulatory status after the WRC has concluded its deliberations.

3.2 WRC-03

The results of World Administration Radiocommunication Conferences are considered treaties, and recognized as international law. The United States, unless it has indicated a Reservation concerning some particular provision of the treaty, normally has implemented the results of the treaties into its own domestic rules and regulations. Therefore, the modifications or additions to the Radio Regulations resulting from WRC-03 should be considered mandatory. The modifications to the Radio Regulations in response to Agenda Item 11.1 are indicated in the table below.

WRC-03 AMSS Provisions

Allocation	Footnote
14-14.25 GHz	5.504C
14.25-14.3 GHz	5.508A
14.3-14.4 GHz	5.509A
14.4-14.47 GHz	5.509A
14.47-15.5 GHz	5.504B, 5.509A

The texts of these footnotes may be found at Appendix C. 5.504B makes reference to the provisions of Annex 1, Part C of Recommendation ITU-R M.1643, and 5.504C, 5.508A, and 5.509A make reference to Annex 1, Part B of this Recommendation. The nature of

the references to this Recommendation is considered to be "Incorporation by Reference" into the Radio Regulations of those parts of the Recommendation which are mentioned. Thus, the referenced parts of the Recommendation have the same mandatory status as the Radio Regulations themselves. It should be noted that there is no mention of Annex 1, Part A of this recommendation in the Radio Regulations. Therefore, Part A does not have treaty status and may be treated as advisory in nature as discussed in section 2.0 of this report.

Thus, the only mandatory aspects of WRC-03 and Recommendation ITU-R M.1643 are not questioned in comments on the ARINC SKYLink Application. The SKYLink Application proposes to meet those requirements of the referenced footnotes in the 14 – 14.5 GHz band, including any part of the Recommendations incorporated by reference. There are no comments made to the application which suggest that this system would or could not meet such requirements.

4.0 Aggregation of Off-Axis Emissions and Pointing Accuracy

Commenters on the SKYLink application have asserted that antenna pointing error has not been taken account of in ARINC's calculation of off-axis e.i.r.p., and that this is inconsistent with ITU-R M 1643. However, it appears that these comments are attempting to mandate something which is not mandated.

In Attachment 1 to its SKYLink Application, ARINC has indicated that it meets the off-axis aggregate e.i.r.p. Spectral Density control requirement. How this is accomplished is described in Section 5.2.1.2 of the Application. According to this description, "the GES monitors the number of active aircraft and number of simultaneous transmissions and adjusts transmitted power on airborne units (down to the minimum power consistent with their signaling rate) so that the aggregate e.i.r.p. remains below –24.25 dBW/4kHz." ARINC also addresses antenna mis-pointing in Sections 3.1.2.2, 3.1.3.1, and 3.1.3.2 of its SKYLink Application. ARINC indicates that the total root mean square pointing error for the antenna is calculated to be less than 0.1°. This value has been questioned by commenters but no evidence was provided to support the comment.

The commenter also asserts that Ku-band AMSS systems "must" specifically account for pointing error. However, a review of the Radio Regulations does not indicate

any mandatory requirement to "specifically account for pointing error in determining off-axis e.i.r.p." Appendix D is a list of the titles of ITU-R FSS Recommendations. Some deal with interference aggregation and some deal with pointing error. None concern both. While Recommendation ITU-R M.1643, Parts B and C have been incorporated into the Radio Regulations by reference, Part A—which discusses pointing error—has not.

It should further be noted that an ITU-R Recommendation adopted recently, for Earth Stations on Board Vessels (See Characteristics of ESV, ITU-R Rec. S.1587), does not include a requirement to take account of mis-pointing in the calculation of off-axis e.i.r.p. There is an indication in this Recommendation of the need to maintain a pointing error ±0.2°, which the SKYLink Application indicates the SKYLink system can meet.

The most important part of such systems is being able to assure that any interference created by the transmissions will be maintained within the envelope of the interference characteristics of the coordinated FSS network which is being used for the service, and that the pointing is able to be maintained appropriately.

5.0 Conclusion

This assessment has examined comments on the SKYLink Application in respect to A) ITU-R Radio Regulations and Recommendations in Relation to Access Control; B) Requirements of ITU-R Decisions, and C) Aggregation of Interference Related to Off-Axis Emissions and Pointing Accuracy. This assessment has indicated that:

- There is no ITU-R Radio Regulation which mandates that access control be accomplished through "positive" control. Indeed, the only thing close, Part A of Recommendation ITU-R M.1643, states that monitoring and control should be done by an NCMC or equivalent facility.
- The only mandatory parts of Recommendation ITU-R M.1643 are Parts B and C of Annex 1, which have been incorporated by reference into several footnotes to the Radio Regulations in the 14-14.5 GHz band.
- There are no ITU-R Rules or Regulations, or Recommendations that prohibit or question the ARINC method of calculating aggregate off-axis interference.

APPENDIX A

RECOMMENDATION ITU-R M.1643

RECOMMENDATION ITU-R M.1643*

Technical and operational requirements for aircraft earth stations of aeronautical mobile-satellite service including those using fixed-satellite service network transponders in the band 14-14.5 GHz (Earth-to-space)

(2003)

Summary
This Recommendation provides the technical and operational requirements for aircraft earth stations (AES) of aeronautical mobile-satellite service (AMSS), including those using FSS network transponders operating in the band 14-14.5 GHz (Earth-to-space), that should be used by administrations as a technical guideline for establishing conformance requirements for AES and facilitating their licensing, for worldwide use.

The ITU Radiocommunication Assembly,

considering

a) that various technically and operationally different aeronautical mobile-satellite service (AMSS) networks have been designed to commence operation in the near future;

b) that these planned AMSS networks may provide access to a variety of broadband communication applications (Internet, email, internal corporate networks) to and from aircraft on a global basis;

c) that the aircraft earth station (AES) will operate on national and international airlines around the world;

d) that circulation of AES is usually a subject of a number of national and international rules and regulations including satisfactory conformance to a mutually agreed technical standard and operational requirements;

e) that there is a need for identifying the technical and operational requirements for the conformance testing of AES;

f) that the identification of technical and operational requirements for AES would provide a common technical basis for facilitating conformance testing of AES by various national and international authorities and the development of mutual recognition arrangements for conformance of AES;

g) that the technical and operational requirements need to achieve an acceptable balance between radio equipment complexity and the need for effective use of the radio-frequency spectrum,

considering also

a) that in the frequency band 14-14.5 GHz there are allocations to the FSS (Earth-to-space), radionavigation, fixed and mobile (except aeronautical mobile) services on a primary basis; that secondary services allocated in the band 14-14.5 GHz or in parts of

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* NOTE – The Arab Group represented at RA-03 reserves its position on this Recommendation and is not ready to accept any repercussions with respect to WRC-03 Agenda item 1.11.

the band include mobile-satellite (except aeronautical mobile-satellite) service (Earth-to-space), space research service (SRS), radio astronomy service (RAS), and radionavigation-satellite service;

b) that there is a requirement to fully protect all primary services and pre-existing systems of secondary services in the band 14-14.5 GHz;

c) that results of the studies conducted in accordance with Resolution 216 (Rev.WRC-2000) showed the feasibility of using the band 14-14.5 GHz by AMSS (Earth-to-space) on a secondary basis under certain conditions and arrangements[1];

d) that the identification by ITU-R of technical and operational requirements for AES operating in the band 14-14.5 GHz could assist administrations to prevent harmful and/or unacceptable interference to other services;

e) that technical and operational characteristics should be continuously and accurately measurable and controllable,

recommends

1 that the technical and operational requirements[1] for aircraft earth stations of AMSS networks operating in the band 14-14.5 GHz given in Annexes 1 and 2 be used by administrations as a guideline for:

- establishing conformance requirements for AES;
- facilitating AES operations.

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[1] The characteristics of the typical aircraft earth stations need to fulfil the requirements described in this Recommendation and, further, need to be within the envelope of those initiallypublished in the International Frequency Information Circular (BR IFIC) relating to the corresponding FSS network. In the case that the characteristics are outside of the envelope of those in the initial publication, the required coordination of such an aircraft earth station needs to be effected in accordance with the current provisions of the Radio Regulations (RR) and a modified Rule of Procedure as contained in § 2 of the Rules of Procedure relating to RR No. 11.32, as appropriate.

Annex 1

Technical and operational requirements for AES of AMSS networks in the band 14-14.5 GHz (Earth-to-space)

Part A

Essential requirements related to the protection of FSS networks

1 AMSS networks should be coordinated and operated in such a manner that the aggregate off-axis e.i.r.p. levels produced by all co-frequency AES within AMSS networks are no greater than the interference levels that have been published and coordinated for the specific and/or typical earth station(s) pertaining to FSS networks where FSS transponders are used.

2 The design, coordination and operation of an AES should, at least, account for the following factors which could vary the aggregate off-axis e.i.r.p. levels generated by the AES:

2.1 mispointing of AES antennas. Where applicable, this includes, at least, effects caused by bias and latency of their pointing systems, tracking error of closed loop tracking systems, misalignment between transmit and receive apertures for systems that use separate apertures, and misalignment between transmit and receive feeds for systems that use combined apertures;

2.2 variations in the antenna pattern of AES. Where applicable, this includes, at least, effects caused by manufacturing tolerances, ageing of the antenna and environmental effects. AMSS networks using certain types of AES antennas, such as phased arrays, should account for variation in antenna pattern with scan angles (elevation and azimuth). Networks using phased arrays should also account for element phase error, amplitude error and failure rate;

2.3 variations in the transmit e.i.r.p. from AES. Where applicable, this includes, at least, effects caused by measurement error, control error and latency for closed loop power control systems. Network control and monitoring centres (NCMCs) that calculate the e.i.r.p. of AES based on the received signal need to take into account error sources and latency in this calculation. NCMCs that calculate the e.i.r.p. of AES based on input power must account for measurement error and reporting latency.

3 AES that use closed loop tracking of the satellite signal need to employ an algorithm that is resistant to capturing and tracking adjacent satellite signals. AES must immediately inhibit transmission when they detect that unintended satellite tracking has happened or is about to happen.

4 AES should be subject to the monitoring and control by an NCMC or equivalent facility. AES must be able to receive at least "enable transmission" and "disable transmission" commands from the NCMC. AES must automatically cease transmissions

immediately on receiving any "parameter change" command, which may cause harmful interference during the change, until it receives an "enable transmission" command from its NCMC. In addition, it should be possible for the NCMC to monitor the operation of an AES to determine if it is malfunctioning.

5 AES need also to be self-monitoring and, should a fault which can cause harmful interference to FSS networks be detected, the AES must automatically mute its transmissions.

Part B

Essential requirements related to the protection of the fixed service

In the 14-14.5 GHz frequency band as used by fixed service networks, within line-of-sight of the territory of an administration where fixed service networks are operating in this band, the maximum pfd produced at the surface of the Earth by emissions from a single AES, of an AMSS network should not exceed:

$-132 + 0.5 \cdot \theta$	$dB(W/(m^2 \cdot MHz))$	for $\theta \leq 40°$
-112	$dB(W/(m^2 \cdot MHz))$	for $40 < \theta \leq 90°$

where θ is the angle of arrival of the radio-frequency wave (degrees above the horizontal).

NOTE 1 – The aforementioned limits relate to the pfd and angles of arrival that would be obtained under free-space propagation conditions.

NOTE 2 – An e.i.r.p. mask can be derived from the aforementioned pfd mask by applying the method given in Annex 2 of this Recommendation. Simplification of the resulting e.i.r.p. mask could also be considered.

Part C

Essential requirements related to sharing with the RAS

In order to protect the radio astronomy in the band 14.47-14.5 GHz, AMSS earth stations should comply with both following measures:

AMSS channels in the 14.47-14.5 GHz band

- AMSS stations do not transmit in the 14.47-14.5 GHz band within line-of-sight of radio astronomy stations operating within this band;

  or,

- if an AMSS operator intends to operate co-frequency within the visibility of the radio astronomy station, a specific agreement with the radio astronomy station will be needed to ensure that AMSS AES will meet the requirements of Recommendations ITU-R RA.769 and ITU-R RA.1513 within the 14.47-14.5

GHz band during observations. Where practicable, this may include advance information to AMSS operators regarding observation schedules.

AMSS channels in the 14-14.47 GHz band

All AES transmitters on channels in the 14-14.47 GHz band within line-of-sight of radio astronomy stations during radio astronomy observations have emissions in the band 14.47-14.5 GHz such that they meet the levels and percentage of data loss given in Recommendations ITU-R RA.769 and ITU-R RA.1513. Results from studies show that the following AES pfd levels (dB(W/(m^2 · 150 kHz))) in the band 14.47-14.5 GHz are sufficient, with some margin, to meet the radio astronomy pfd levels in Recommendation ITU-R RA.769 and the percentage of data loss given in Recommendation ITU-R RA.1513, i.e.:

$-190 + 0.5 \cdot \theta$	dB(W/(m^2 · 150 kHz))	for $\theta \leq 10°$
-185	dB(W/(m^2 · 150 kHz))	for $10° < \theta \leq 90°$

where θ is the angle of arrival of the radio-frequency wave (degrees above the horizontal).

Such AES pfd levels in the band 14.47-14.5 GHz may be achieved by the AMSS operators through a combination of reduced AES signal power, sharp filtering, maintaining adequate frequency separation, or better AES antenna performance.

Part D

Essential requirements related to sharing with the space research service

Coordination agreements should be developed between AMSS and space research systems based on controlling the emissions levels of the AES in the frequency band used by the SRS systems, and, in severe cases, may require cessation of AES emissions on frequencies used by the SRS system when operating in the vicinity of the space research earth station. Specifics of the agreements will vary based on the characteristics of the individual SRS sites and the AMSS networks.

Annex 2

Derivation of a lower hemisphere e.i.r.p. mask from a pfd mask

In testing AMSS equipment to determine if it meets a given pfd mask, such as the one in Annex 1, Part B, it may be useful to determine an equivalent e.i.r.p. mask that can be used for testing purposes.

The pfd mask, pfd(θ) where θ is the angle of arrival (elevation angle) at the Earth's surface, can be used to mathematically determine an e.i.r.p. mask, e.i.r.p.(γ, H) where γ is the angle below the local horizontal plane and H is the altitude of the aircraft. This conversion proceeds in two steps. First, γ is converted to an equivalent angle of arrival, θ.

Then the length of the propagation path for angle of arrival θ is determined and used to calculate the spreading loss for the path and the resulting e.i.r.p.

Step 1: Calculation of an angle of arrival in degrees, θ, from γ and *H*:

$$\theta = \arccos((R_e + H)\cos(\gamma)/R_e)$$

where:

θ: angle of arrival

R_e: earth radius (6 378 km)

H: altitude of the aircraft (km)

γ: angle below horizontal.

NOTE 1 – If the argument of the arccos function is greater than 1, the propagation path in the direction of the angle γ does not intersect the Earth. In this case, which occurs for values of γ of about 3.5° or less, a value for θ does not exist and so there is no defined value for the pfd mask.

Step 2: Calculation of the e.i.r.p. value from the defined pfd(θ):

$$d = (R_e^2 + (R_e + H)^2 - 2\,R_e(R_e + H)\cos(\gamma - \theta))^{1/2}$$

$$\text{e.i.r.p.}(\gamma, H) = \text{pfd}(\theta) + 10\log_{10}(4\,\pi\,d^2) + 60$$

where:

d: distance between the AES and the considered point on the Earth's surface (km)

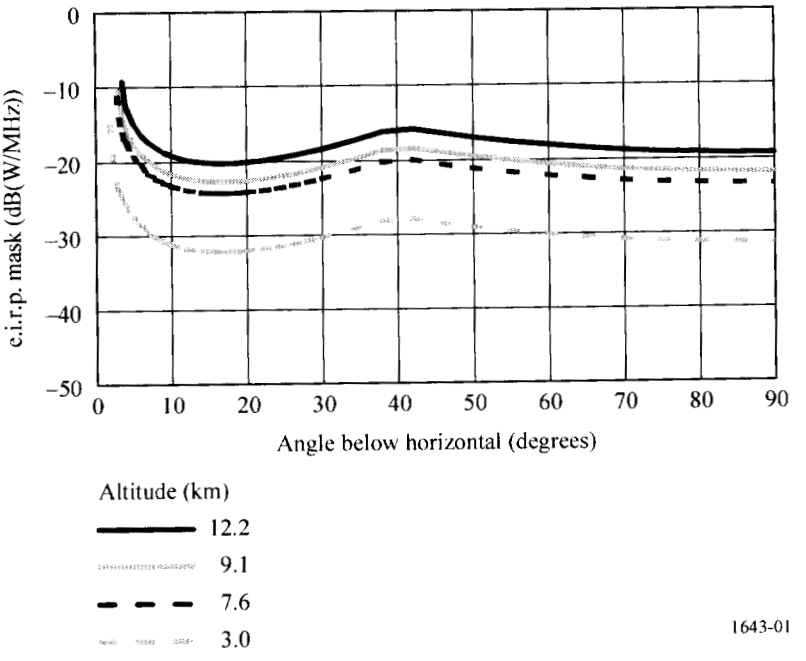
pfd(θ): (dB(W/(m^2 · MHz)))

e.i.r.p.: (dB(W/MHz)).

The graph in Fig. 1 shows this function for various aircraft altitudes based on the pfd mask provided in Annex 1, Part B of this Recommendation.

FIGURE 1

e.i.r.p. mask derived from pfd mask



APPENDIX B

SECTION 2.4 OF CPM-02 REPORT

2.4 Agenda item 1.11

"to consider possible extension of the allocation to the mobile-satellite service (Earth-to-space) on a secondary basis in the band 14-14.5 GHz to permit operation of the aeronautical mobile-satellite service as stipulated in Resolution **216 (Rev.WRC-2000)**"

2.4.1 Summary of technical and operational studies, including a list of relevant ITU-R Recommendations

Relevant ITU-R Recommendations: S.728-1, RA.611, RA.769, RA.1513, SA.510, SA.1155, SA.1414; F.758, F.1094, F.1245 and DNR M.[AMSS].

2.4.1.1 Introduction

AMSS in the 14-14.5 GHz band is being proposed to meet a growing demand for two-way broadband communications by passengers and operators of commercial aircraft.

All or parts of the band 14-14.5 GHz are allocated on a primary basis to the FSS (Earth-to-space), RNS, and FS and MS (except aeronautical mobile service). Secondary services allocated in all or parts of the band include: MSS (Earth-to-space) (except AMSS), SRS, RAS, and RNSS. To achieve the objective of Resolution **216 (Rev.WRC-2000)**, studies were carried out to assess "the feasibility of sharing the band 14-14.5 GHz between the services referred to in *considering c)* and the aeronautical mobile-satellite service, with the latter service on a secondary basis." In addition, studies were carried out by the ITU-R with systems operating in secondary allocations in the band using available data as well as that obtained as a result of an Administrative Circular (CA/91).

Liaison statements among the concerned working parties exchanged information on the technical characteristics of the terminals of these services, as well as on analytical methodologies for, and results of, compatibility/sharing analyses. In addition, an Administrative Circular (CA/91) was sent by the Director of the BR requesting administrations to provide information on certain types of their use of the band 14-14.5 GHz, for which there were a limited number of replies.

2.4.1.2 Compatibility with services having primary allocations in the band 14-14.5 GHz

2.4.1.2.1 Fixed-satellite service (FSS) (14-14.5 GHz)

One central factor in the design of the planned AMSS network used for the FSS compatibility studies, is that the 14 GHz transmissions from the aircraft earth stations (AES) would be received by space station facilities that were coordinated with adjacent satellites. A second central design factor of the AMSS system is that the individual AES transmissions would be under the positive control of a network control and monitoring centre (NCMC), which would limit the aggregate off-axis, co-frequency, e.i.r.p. levels

from multiple AES at adjacent satellites to (or below) those levels that have been accepted by other satellites, including, *inter alia*, effects of antenna pattern variations and pointing stability.

The AMSS networks will need rigorous protocols to control the operation of AES to be within the agreed limits. These controls include: entry of AES into the network; authorization for the AES to transmit; authorization to change transmit power/data rates and frequency assignment; and the ability to terminate AES transmissions. An NCMC must manage AES transmission levels within ranges both on an individual and on an aggregate (per transponder) basis.

Taking into account the planned AMSS networks in the 14-14.5 GHz band, studies were conducted to determine the feasibility of operating in the band on a secondary basis with the FSS.

The compatibility study with the FSS was begun by constructing a Monte Carlo simulation of a planned AMSS network, including the ability to evaluate the impact of transmissions from adding AES, and sources of random errors and inherent latencies for each co-frequency AES in the system. Running over 100 000 trials of the simulation determined that the NCMC could control the aggregate off-axis e.i.r.p. levels to those of Recommendation ITU-R S.728-1 for both 2° and 3° GSO satellite spacing to a 99.99% confidence level. This analysis verified that it was feasible to control the aggregate off-axis e.i.r.p. density levels from an AMSS network to be no greater than that of coordinated VSATs, as characterized in Recommendation ITU-R S.728-1.

Another study examined whether the cumulative interference from an AMSS network would cause harmful interference to non-GSO space station receivers.

2.4.1.2.2 Radionavigation service (RNS) (14-14.3 GHz)

There are no records in the ITU Master Register indicating use of the radionavigation allocation in the 14-14.3 GHz band by any administration. No additional information was obtained on radionavigation use of the band as a result of enquiries within the ITU-R and the BR Administrative Circular (CA/91). Consideration of compatibility matters has not revealed a problem in the use of this band by AMSS with respect to RNS.

2.4.1.2.3 Fixed service (FS) (14.4-14.5 GHz); (Regions 1 and 3: 14.3-14.4 GHz); (5.505: 14-14.3 GHz); (5.508: 14.25-14.3 GHz)

In the 14-14.5 GHz range, the FS is allocated on a primary basis in the band 14-14.3 GHz by No. **5.505**, in the band 14.25-14.3 GHz by No. **5.508**, in the band 14.3-14.4 GHz in Regions 1 and 3 and in the band 14.4-14.5 GHz in all three Regions.

Technical feasibility studies were performed by a number of administrations to determine whether planned AMSS networks could operate without causing harmful interference to the fixed service systems operating in the 14-14.5 GHz band.

These studies analysed the interference from planned AMSS networks by determining a pfd mask or e.i.r.p. mask that would not cause harmful interference to the systems in the FS. This was achieved by setting up a model of air traffic routes and fixed service receivers. The aggregate levels of interference into the fixed service networks due to emissions from planned AMSS networks were then calculated. The air traffic scenario was based upon the air traffic routes over the United Kingdom, Australia, France and Russia. Some studies used actual traffic routes with random variations in the time of arrival of the aircraft and deviation of the aircraft flight from the selected route. Other studies used worst-case scenarios in which deterministic air traffic routes were along the main beam region of the fixed service station. Aggregate levels of interference were calculated as a function of time and I/N exceedence curves were presented to describe the long-term and short-term levels of interference caused by the chosen air traffic scenario, pfd or e.i.r.p. mask and aircraft altitudes. As far as interference from the planned AMSS networks is concerned, it was agreed that the following interference assessment levels should apply:

- Long-term

I/N = –20 dB to be exceeded for no more than 20% of time or an FDP (Fractional Degradation in Performance) not to exceed 1%.

- Short-term

A permissible interference level of –125 dB(W/MHz) not to be exceeded.

A pfd mask to protect the FS was developed on the basis of the assessment levels given above.

2.4.1.2.4 Mobile service (MS) (except aeronautical mobile) (14.4-14.5 GHz); (Regions 1 and 3: 14.3-14.4 GHz); (5.509: 14.25-14.3 GHz)

There are no records in the ITU Master Register indicating any use of the MS allocation in the band. No additional information was obtained on mobile service use of the band as a result of inquiries within the ITU-R, nor as a result of the BR Administrative Circular (CA/91).

However, based on information received in the course of conducting studies with the FS, it was learned that the band is used by some administrations for electronic news gathering (ENG) (the service is termed temporary-fixed by some administrations). Since ENG is considered by some administrations as a mobile service, and the system aspects of ENG are similar to those of the FS, the methodology recommended for AMSS studies with the FS was employed for such MS studies using ENG network characteristics.

2.4.1.3 Compatibility with services having secondary allocations in the band 14-14.5 GHz

2.4.1.3.1 Radio astronomy service (RAS) (14.47-14.5 GHz)

The RAS systems operate at relatively few sites around the world and uses antennas with a gain greater than 65 dBi. The radio astronomy observations in this band are important, but at some observatories, observations are carried out only for a small fraction of the time.

Sharing studies were performed using two alternative methodologies to determine if sharing between the RAS and the AMSS networks would be feasible in the 14-14.5 GHz band.

a) One study applied the Recommendation ITU-R RA.769 pfd level of –221 dB(W/(m2 · Hz)) to the AES emissions and derived the required AES pfd values to protect the RAS receiver.

b) The second study used the simulation methodology developed for sharing studies between non-GSO satellite systems and the RAS. This methodology, developed in Recommendation ITU-R M.1583, consists in a division of the sky into cells of approximately equal solid angles and in calculation of the epfd generated by all aircraft for each cell, averaged over time slots of 2 000 seconds. This methodology also assumes worst-case assumptions for the AMSS interference environment. Temporal statistics are obtained by performing a sufficient number of trials, randomly changing the RA station antenna pointing direction within a cell and the position of aircraft from one trial to another. The study showed that, above a 5?elevation angle, the epfd limit of –303 dB(W/(m2 · Hz)) (derived from Recommendation ITU-R RA.769 and the RAS antenna peak gain) was exceeded for less than 2% of the time (this criterion comes from Recommendation ITU-R RA.1513).

2.4.1.3.2 Space research service (SRS) (14-14.3 GHz) and (14.4-14.47 GHz)

Sharing studies were performed to determine if it is feasible for AES in the AMSS to share the 14-14.3 GHz and 14.4-14.47 GHz bands with the SRS on a secondary basis. Data relay satellite (DRS) networks use earth stations in the SRS at a very few sites in the world. These studies showed that the use of AMSS in this band is feasible.

2.4.1.3.3 Radionavigation-satellite service (RNSS) (14.3-14.4 GHz)

There are no records in the ITU Master Register indicating any use of the RNSS allocation in the 14.3-14.4 GHz band. Nor is there any record in any BR list of a prior Advance Publication Information (per No. **9.1**) by an administration for use of the band by RNSS. Nor was any information on proposed RNSS use of the band provided by administrations in response to the BR Administrative Circular (CA/91). Consideration of

sharing matters has not revealed a problem on the use of this band by AMSS with respect to the RNSS.

2.4.1.3.4 Mobile-satellite service (MSS) (except AMSS) (14.0-14.5 GHz)

MSS (except AMSS) systems, in the 14-14.5 GHz band, are operational in all three ITU Regions. Through the data reported in response to CA/91, it was learned that MSS use of the 14-14.5 GHz band requires that the MSS systems operate such that the aggregate, off-axis e.i.r.p. of all co-frequency transmissions is within the limits set by the administrations wherein these systems are employed. These limits have been based on the principles of, and closely related to, the limits developed during the adoption of Recommendation ITU-R S.728-1, as is appropriate for the satellite spacing environment. Since these existing MSS networks have a secondary status, they must accept interference from primary users of the band, but can claim protection against harmful interference from users of new secondary allocations, such as the AMSS.

A study was conducted to determine the ability of a planned AMSS network to share the band 14-14.5 GHz with an operational MSS network. The study concluded that sharing is feasible.

2.4.2 Analysis of the results of studies

On the basis of information available from the ITU-R studies, it has been demonstrated that it is feasible for appropriately designed AMSS networks to be operated on a secondary basis in the band 14-14.5 GHz without causing harmful interference to primary services in the band. Additional studies have shown the feasibility of AMSS sharing with services employing secondary allocations in the band.

2.4.2.1 Analysis of studies involving the primary allocations in the band

2.4.2.1.1 Fixed-satellite service

The studies show that an AMSS system operating on a secondary basis can compatibly operate with the FSS in the 14-14.5 GHz frequency band, provided aggregate co-frequency AES emissions in the direction of adjacent satellites are limited to levels that are equal to or less than the levels that have been accepted by other satellite networks. These conclusions apply equally to GSO and non-GSO FSS.

In addition, DNR ITU-R M.[AMSS] provides guidance to system designers and licensing administrations regarding technical and operating parameters of AMSS networks in the band 14-14.5 GHz needed to permit operation of AMSS networks with the FSS in the band.

2.4.2.1.2 Radionavigation service

Based on the information available, AMSS use of this band does not present any difficulty.

2.4.2.1.3 Fixed service

A general conclusion of the studies was that the dominant interference effect occurs as a result of an aircraft flying through the main beam of an FS antenna producing short-term interference and also significantly influencing the long-term FDP.

Results of the interference analyses have concluded that the following pfd mask applied to the AES of an AMSS network would adequately protect the fixed service networks in the band 14-14.5 GHz:

pfd = –132 + 0.5*. dB(W/m2) in 1 MHz for . = 40°
pfd = –112 dB(W/m2) in 1 MHz for 40 < . = 90°

Where . is the angle of arrival, measured in degrees.

FS protection could also be ensured by a consistent e.i.r.p. mask, which can be derived for any given altitude from the above pfd mask using the conversion formula in Annex 2 of DNR ITU-R M.[AMSS]. Simplification of the resulting e.i.r.p. mask could also be considered.

2.4.2.1.4 Mobile service

Since there are no known mobile service systems using this allocation, a sharing analysis was accomplished employing characteristics of ENG systems that do use the allocation. These studies showed that the use of AMSS in this band is feasible, based on the information available.

2.4.2.2 Analysis of studies involving secondary allocations in the band

2.4.2.2.1 Radio astronomy service

Based on the studies described in § 2.4.1.3.1, both of which came to the same conclusion, it was concluded that sharing is feasible between the AMSS networks and the RAS in the 14-14.5 GHz band, provided that the following conditions are met:

1) AMSS Channels in the 14.47-14.5 GHz band

a) AMSS stations do not transmit in the 14.47-14.5 GHz band within line-of-sight of radio astronomy stations operating within this band;

or,

b) if an AMSS operator intends to operate co-frequency within the visibility of the RA station, a specific agreement with the RA station will be needed to ensure that AMSS AES will meet the requirements of Recommendations ITU-R RA.769 and RA.1513 within the 14.47-14.5 GHz band during observations. When practicable, this may include advance information to AMSS operators regarding observation schedules.

2) AMSS channels in the 14-14.47 GHz band

All AES transmitters on channels in the 14-14.47 GHz band, within line of sight of radio astronomy stations during radio astronomy observations have emissions in the band 14.47-14.5 GHz such that they meet the levels given in Recommendation ITU-R RA.769. Results from studies show that the following AES pfd levels in the band 14.47-14.5 GHz are sufficient, with some margin, to meet the RAS power flux-density levels in Recommendation ITU-R RA.769, i.e.:

pfd = –190 + 0.5*. dB(W/m2) in 150 kHz for . = 10°
pfd = –185 dB(W/m2) in 150 kHz for 10?< . = 90°

Where . is the angle of arrival, measured in degrees.

Such AES pfd levels in the band 14.47-14.5 GHz may be achieved by the AMSS operators through a combination of reduced AES signal power, sharp filtering, maintaining adequate frequency separation, or enhanced AES antenna performance.

2.4.2.2.2 Space research service

Based on the studies described in section 2.4.1.3.2, it was concluded that it is feasible for the AMSS to share with the space research service in the 14-14.3 GHz and 14.4-14.47 GHz bands, and that sharing can be accomplished through coordination as per RR Article **9**. It was determined that the main mechanism for interference occurs when an AES transmits in or near the main beam of the SRS antenna. In such a situation, coordination between the two networks is the most appropriate method for ensuring compatibility. The studies indicated that the coordination agreements between AMSS and space research networks can be developed based on controlling the emissions levels of the AES and, in severe cases, may require cessation of AES emissions in the frequency band used by the SRS networks when operating in the vicinity of the space research earth station. Specifics of the agreements will vary based on the characteristics of the individual SRS sites and the AMSS networks. Such emission restrictions are feasible for the AMSS.

2.4.2.2.3 Radionavigation-satellite service

Since there are no RNSS systems using, or proposing to use this secondary allocation, use of the band by AMSS is feasible.

2.4.2.2.4 Mobile-satellite service (except AMSS)

Analyses confirmed that interference protection margins make it feasible for AMSS and MSS (except AMSS) networks to share the band 14-14.5 GHz, both on a secondary basis, when they employ co-frequency transponders on adjacent satellites.

2.4.3 Methods to satisfy the agenda item and their advantages and disadvantages

Each of the regulatory and procedural alternatives that could be used for satisfying the agenda item to provide for the secondary AMSS allocation in the band 14-14.5 GHz requires removal from the existing MSS allocation of the phrase "*except aeronautical mobile-satellite*". Each alternative is presented below, along with the advantages and disadvantages of each.

The Arab Administrations stated their reservations with regard to all the methods proposed under this agenda item.

2.4.3.1 Method A

Remove the restriction "***except aeronautical mobile-satellite***" from the Table of Frequency Allocations in Article **5** for the MSS in the frequency band 14-14.5 GHz.

Under this option the phrase "*except aeronautical mobile-satellite*" would be removed from the secondary MSS allocation for 14-14.5 GHz in the Table of Frequency Allocations. No further modifications of the RR to protect other services from harmful interference would need to be incorporated.

Advantage:

Some administrations believe that compliance with the existing provisions of the RR would be sufficient. This is the simplest approach for satisfying the agenda item as the regulatory status of a secondary service and related procedures are well defined in the Radio Regulations. Since the service is to be secondary, it is obliged to protect all primary services and pre-existing systems of secondary services can claim protection from harmful interference, and also the AMSS must accept harmful interference from primary services and pre-existing secondary services.

Disadvantage:

The compatibility/sharing conditions that were identified by the ITU-R as contained in DNR ITU-R M.[AMSS] for protecting certain other services will not be explicitly referred to in the RR. In this case the application of DNR ITU-R M.[AMSS] and/or other criteria is left to administrations to satisfy the requirements to protect other services. Hence, some administrations believe that the protection of primary terrestrial and pre-existing systems of secondary services is not ensured as it may be difficult to detect and

localize the interference source, and this may not allow administrations to intervene to make interferers cease their transmissions. Some administrations believe that even in the case where the interferer would be determined, it would be necessary to justify and negotiate the level of harmful interference.

2.4.3.2 Method B

Remove ***"except aeronautical mobile-satellite"*** from the Table of Frequency Allocations in Article **5** and add a footnote that incorporates by reference ITU-R Recommendation DNR ITU-R M.[AMSS].

Advantages:

Some administrations believe that this would ensure the appropriate protection of the fixed service and the radio astronomy service by enforcing the necessary limitations in the RR. For the convenience of licensing authorities, the compatibility/sharing conditions for protecting certain other services will be explicitly referenced and that this would be of assistance to administrations. Including limits in the RR identifies to AMSS operators clear operating guidelines relative to other services.

Disadvantages:

Some administrations believe that this might not be consistent with the principle that adding footnotes to the Radio Regulations or referring to additional ITU-R Recommendations in them should be avoided where possible, and that inclusion of limits in the RR for the protection of primary services from interference caused by the secondary service would not be consistent with the current status of secondary services and could be interpreted ambiguously by Administrations. Changes in Recommendations incorporated by reference into the RR must be approved by a competent WRC.

2.4.4 Regulatory and procedural considerations

In Method A, there are no consequential RR procedural changes or additions required. Existing regulatory procedures are adequate to deal with the modification to Article **5**. The modification is to remove the restriction "*except aeronautical mobile-satellite*" from the Table of Frequency Allocations in Article **5** for MSS in the frequency band 14-14.5 GHz.

In Method B, the modification is to remove the restriction "*except aeronautical mobile-satellite*" from the Table of Frequency Allocations in Article **5** for MSS in the frequency band 14-14.5 GHz and there would be regulatory or procedural changes required. This would be achieved by adding a footnote to Article **5** of the RR that incorporates by reference DNR ITU-R M.[AMSS], and by way of example, this footnote could read:

ADD

5.AMSS In the band 14-14.5 GHz, aircraft earth stations in the aeronautical mobile-satellite service shall operate in accordance with the provisions of Annex 1 of DNR ITU-R M.[AMSS]. The pfd limits in Annex 1 may be exceeded on the territory of any country whose administration has so agreed.

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It is worth noting that the latter sentence of this example footnote is consistent with No. **21.17**, which applies to pfd limits as described in Table 21-4.

Under Method B, even though the AMSS complies with the limits, in no way should it detract from being a secondary service, and therefore in the event it causes harmful interference, it will have to immediately eliminate the harmful interference.

For Methods A and B the case of the protection of other secondary services is addressed in DNR ITU-R M.[AMSS].

For Methods A and B in order to use AMSS on a secondary basis in the frequency band 14-14.5 GHz, a request for coordination of the AMSS network is to be submitted to the BR. Under Article 9, this leads to the publication of a Special Section of the BR International Frequency Information Circular (BR IFIC). This publication is to initiate the coordination procedure for the AMSS network where the class of station is matched for the space station and earth station, and the space station and earth station have the same category of allocation. This publication could take the form of a new AMSS network or the modification of an existing network to include the AMSS operations. Any earth station other than that published with the above-mentioned new Special Section (aeronautical mobile-satellite service with secondary allocation) must have the characteristics within the limits of those published by the Bureau or it should have to undergo the coordination procedure of Article 9. These actions could therefore be done within the existing procedures of the Radio Regulations.

With regard to the notification of earth stations pertaining to the AMSS, in addition to that included in the publication procedure referred to in the previous paragraph, some administrations were of the opinion that there would be three possible courses of action:

a) using the current provisions of Article 9 (No. 9.7 and other relevant provisions) or;

b) modifying the relevant part of the Rules of Procedure relating to No. 11.32 or;

c) a new provision (No. 9.7C), the wording of which would indicate that the required coordination needs to be effected by the administration responsible for the AMSS with respect to space services of other administrations whose services are likely to be affected. This coordination requirement should be

identified by the Bureau and carried out by AMSS administrations using Appendix 8 criteria.

Under Methods A and B, WRC-03 may consider suppression of Resolution **216 (Rev.WRC-2000)**.

Some administrations are of the view that, in addition, since no further action by the Conference is needed to implement this proposal, it can be provisionally applied from the end of WRC-03 by including the appropriate provisions in Article 59. Such action will hasten the establishment of the aeronautical mobile-satellite service in this frequency band to meet the growing demand for broadband communications to provide data transmission service for aircraft.

Some other administrations are of the view that the decisions on the date of implementation is outside the mandate of CPM.

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APPENDIX C

Provisions of RR From WRC-03

5.504B Aircraft earth stations operating in the aeronautical mobile-satellite service in the band 14-14.5 GHz shall comply with the provisions of Annex 1, Part C of Recommendation ITU-R M.1643, with respect to any radio astronomy station performing observations in the 14.47-14.5 GHz band located on the territory of Spain, France, India, Italy, the United Kingdom and South Africa. (WRC-03)

5.504C In the band 14-14.5 GHz, the power flux-density produced on the territory of the countries of Saudi Arabia, Botswana, Cote d'Ivoire, Egypt, Guinea, India, Iran, Kuwait, Lesotho, Nigeria, Oman, Syria Arab Republic and Tunisia by any aircraft earth station in the aeronautical mobile-satellite service shall not exceed the limits given in Annex 1, Part B of Recommendation ITU-R M.1643, unless otherwise specifically agreed by the affected administration(s). The provisions of this footnote in no way derogate the obligations of the aeronautical mobile-satellite service to operate as a secondary service in accordance with No. **5.29.** (WRC-03)

5.508A In the band 14.25-14.3 GHz, the power flux-density produced on the territory of the countries of Saudi Arabia, Botswana, China, Cote d'Ivoire, Egypt, France, Guinea, India, Iran, Italy, Kuwait, Lesotho, Nigeria, Oman, Syrian Arab Republic, the United Kingdom and Tunisia by any aircraft earth station in the aeronautical mobile-satellite service shall not exceed the limits given in Annex 1, Part B of Recommendation ITU-R M.1643, unless otherwise specifically agreed by the affected administration(s). The provisions of this footnote in no way derogate the obligations of the aeronautical mobile-satellite service to operate as a secondary service in accordance with N. **5.29.** (WRC-03)

5.509A In the band 14.3-14.5 GHz, the power flux-density produced on the territory of the countries of Saudi Arabia, Botswana, Cameroon, China, Cote d'Ivoire, Egypt, France, Gabon, Guinea, India, Iran, Italy, Kuwait, Lesotho, Morocco, Nigeria, Oman, Syrian Arab Republic, the United Kingdom, Sri Lanka, Tunisia and View Nam by any aircraft earth station in the aeronautical mobile-satellite service shall not exceed the limits given in Annex 1, Part B of Recommendation ITU-R M.1643, unless otherwise specifically agreed by the affected administration(s). The provisions of this footnote in no way derogate the obligations of the aeronautical mobile-satellite service to operate as a secondary service in accordance with No. **5.29.** (WRC-03)

APPENDIX D

ITU-R FSS Recommendations

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1325 Draft modification to Recommendation ITU-R S.1325-2 - Simulation methodologies for determining statistics of short-term interference between co-frequency, co geostationary-satellite orbit fixed-satellite service systems in circular orbits and other non-geostationary-satellite orbit fixed-satellite service systems in circular

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1341 Sharing between feeder links for the mobile-satellite service and the aeronautical radionavigation service in the space-to-Earth direction in the band 15.4-15.7 G the radio astronomy service in the band 15.35-15.4 GHz

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1595 Interference mitigation techniques to facilitate coordination between non-geostationary fixed-satellite service systems in highly elliptical orbit and non-geostatio systems in low and medium Earth orbit

1647 Draft new Recommendation ITU-R S.[Doc. 4/116] - Methodology to determine the worst-case interference among certain types of non-GSO FSS systems in situatic interference exists

1655 Draft new Recommendation ITU-R S.[Doc.4/58] - Interference mitigation techniques and frequency sharing in the bands 37.5-42.5 GHz and 47.2-50.2 GHz betwee fixed-satellite service networks and non-geostationary-satellite fixed-satellite service systems

1656 Draft new Recommendation ITU-R S.[Doc. 4/117] - Outline of a software specification for automating the examination of satellite network filings for compliance Regulations

1672 Draft new Recommendation ITU?R S.[Doc. 4/118] - Guidelines to be used in the event of non-compliance with single-entry operational and/or additional operatio Article 22 of the Radio Regulations

1673 Draft new Recommendation ITU-R S.[Doc. 4/121] - Methodologies for the calculation of the worst-case interference levels from non-geostationary fixed-satellite highly-elliptical orbits into geostationary fixed-satellite service satellite networks operating in the 10 to 30 GHz frequency bands

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