Before the
Federal Communications Commission
Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of:	)	
ARINC Inc.	)	File Nos. SES-AMD-20031223-01860 and SES-LIC-20030910-0126, Call Sign E030205
Application for Blanket Authority to Operate Aboard Aircraft Up To 1000 Technically-Identical Transmit and Receive Mobile Earth Stations in the 11.7-12.2 and 14.0-14.5 GHz Frequency Bands	)	

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Satellite and
Radiocommunications Division
International Bureau

To: The Commission

SUPPLEMENTAL COMMENTS OF THE BOEING COMPANY

The Boeing Company ("Boeing"), by its attorneys, hereby submits its comments on the Amendment to the above-captioned aircraft earth station ("AES") application filed by ARINC Inc. ("ARINC") for its proposed Ku-band Aeronautical Mobile-Satellite Service ("AMSS") system.[1] Boeing also takes this opportunity to provide its views on a written *ex parte* presentation submitted by ARINC in this application proceeding regarding regulatory matters affecting the *ARINC Application*,[2] and to provide additional analysis regarding the interference

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[1] *See* ARINC Inc., Amendment to Application for Blanket Authority to Operate Aboard Aircraft Up To 1000 Technically-Identical Transmit and Receive Mobile Earth Stations in the 11.7-12.2 and 14.0-14.5 GHz Frequency Bands, File No. SES-AMD-20031223-01860 (filed Dec. 23, 2003) ("*ARINC Amendment*"); *see also* Public Notice, Report No. SES-00597 (rel. Apr. 21, 2004) at 1-2; ARINC Inc., Application for Blanket Authority to Operate Aboard Aircraft Up To 1000 Technically-Identical Transmit and Receive Mobile Earth Stations in the 11.7-12.2 and 14.0-14.5 GHz Frequency Bands, File No. SES-LIC-20030910-01261 (filed Sept. 2, 2003) ("*ARINC Application*").

[2] *See* Written Ex Parte Presentation, File No. SES-LIC-20030910-01261 (filed March 11, 2004) (Assessment of Comments on the ARINC Proposed Aeronautical Mobile Satellite Service (AMSS) In The 14.0-14.5 GHz Band (SKYLINK)) ("*ARINC Ex Parte*").

potential of the proposed ARINC system to the Fixed-Satellite Service ("FSS") and other services in the Ku-band.

The *ARINC Amendment* corrects some the technical errors contained in the *ARINC Application,* but fails to address many of the questions raised in this proceeding regarding the operational characteristics of the proposed system, including noted inconsistencies with the requirements of Recommendation ITU-R M.1643.[3] For its part, the *ARINC Ex Parte* urges the Commission to ignore Recommendation ITU-R M.1643. Neither of these filings establish that the proposed ARINC system complies with the domestic and international regulatory requirements for AMSS systems in the Ku-band or provide the requisite analysis of the potential for interference to other users of the Ku-band.

Accordingly, the Commission should defer consideration of the above-captioned application, as amended, until such time as ARINC provides the information necessary to determine whether that its proposed system design is consistent with Recommendation ITU-R M.1643 and would adequately protect other users of the Ku-band.

I. SIGNIFICANT TECHNICAL QUESTIONS REMAIN UNANSWERED REGARDING ARINC'S PROPOSED AMSS OPERATIONS

Boeing fully supports the multiple entry of Ku-band AMSS service providers and has filed a petition for rulemaking to adopt licensing and service rules for all such systems.[4] As discussed in Boeing's extensive comments in this proceeding, however, additional technical

[3] Throughout this pleading, references to Recommendation ITU-R M.1643 are generally intended to refer to the FSS protection requirements set forth in Annex 1, Section A of the Recommendation.

[4] *See* Amendment of Parts 2 and 25 of the Commission's Rules To Allocate Spectrum in the 14-14.5 GHz Band to the Aeronautical Mobile-Satellite Service ("AMSS") and To Adopt Licensing Rules for AMSS Operations in the Ku-Band, Petition for Rulemaking, RM No. 10800 (filed July 21, 2003); *see also* Comments of The Boeing Company, RM No. 10800 (filed Nov. 3, 2003); Reply Comments of The Boeing Company, RM No. 10800 (filed Nov. 18, 2003).

information is required with respect to ARINC's proposed AMSS operations to determine whether its system design can adequately protect other authorized users of the Ku-band. In particular, Boeing has identified specific technical deficiencies in the *ARINC Application* that must be explained, such as the absence of positive control of aircraft earth station ("AES") transmissions and the failure to account adequately for pointing error and other factors in calculating off-axis EIRP as required by Recommendation ITU-R M.1643.[5]

ARINC has conceded many of the deficiencies in its AMSS application, but argues that the commenters' concerns were "largely moot or unfounded" and that the proposed system complies with Recommendation ITU-R M.1643.[6] ARINC now claims, however, in its written *ex parte* submission that the requirements of Recommendation ITU-R M.1643 are inapplicable because that Recommendation constitutes "technical guidance" only and "there is nothing mandatory about it."[7] ARINC goes on to suggest that Commission should simply ignore relevant ITU-R studies describing Ku-band AMSS operational requirements, and the express language of Recommendation ITU-R M.1643 itself, because certain portions of the Recommendation have not been incorporated by reference into the international Radio Regulations.[8] As discussed below, these responses are insufficient to overcome the deficiencies which remain in the *ARINC Application*.

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[5] *See* Comments of the Boeing Company, File No. SES-LIC-20030910-01261, Call Sign E030205 (filed November 14, 2003) ("*Boeing Comments*"); Further Comments of the Boeing Company, File No. SES-LIC-20030910-01261, Call Sign E030205 (filed December 18, 2003) ("*Boeing Further Comments*").

[6] *See generally* Response of ARINC Inc., File No. SES-LIC-20030910-01261, Call Sign E030205 (filed November 28, 2003). ARINC also submitted a revised Technical Appendix that corrected some of the most obvious errors in the application. *See ARINC Amendment.*

[7] *See ARINC Ex Parte* at 4.

[8] *See id.* at 6-9.

A. The *ARINC Amendment* Fails to Address Many of the Technical Issues Regarding the Proposed System

The *ARINC Amendment* consists of five revised pages to its Technical Appendix that correct only some of the technical errors and omissions in the application.[9] There still remain significant issues in ARINC's technical showings which must be addressed by the Commission.

For example, in arguing that the proposed system can operate at frequencies up to 14.44 GHz and adequately protect radio astronomy services, revised page 48 of the Technical Appendix states "[a]s shown in Figure 3-4, the out-of-band emissions from an [AES] are at least 65 dB down at frequencies more than 30 MHz from the band edge."[10] The 65 dB down value is the difference between the maximum emissions level of 0 dB in Figure 3-4 and the level 30 MHz or more beyond the band edge,[11] and is used by ARINC in calculating the level of AES out-of-band emissions that would be received by a radio astronomy observatory. Figure 3-4 does not, however, show the out-of-band emissions from one of ARINC's AESs. The text immediately preceding Figure 3-4 states that the figure shows "[t]he composite Forward and Return link spectrum (single-sided) outside the authorized bandwidth . . . ."[12] In other words, the spectrum in Figure 3-4 comprises both the forward link (hub-to-AES transmission) and return link (AES-to-hub transmission) signals. The in-band spectra of these signals are also shown in Figure 3-3 of ARINC's Technical Appendix, which reveals that the maximum power spectral density ("PSD") of the AES (return link) signal is 20 dB lower than the PSD of the composite signal. Combining the two signals in Figure 3-4 effectively masks the out-of-band emission level of the

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[9] *See ARINC Amendment* (revised pages 43, 44 and 47-49).

[10] *Id.* at 48; *see also id.* at 18.

[11] *See id.* at 18.

[12] *Id.*

much lower AES (return link) signal.[13] Because the out-of-band power reduction for the AES (return link) signal could be as small as 45 dB (rather than the stated 65 dB), the proposed AES transmissions could cause up to 20 dB more interference into radio astronomy stations.

More fundamentally, the *ARINC Amendment* fails to address many of the technical deficiencies in the *ARINC Application* identified by Boeing, such as (i) the lack of positive control over AES transmissions; (ii) the failure to account for numerous variables in the calculation of aggregate off-axis EIRP of AES transmissions, including pointing error, reverse calculation errors, control latency issues, and the effect of co-frequency forward link and return link operations; and (iii) the control of off-axis EIRP to only a 99% confidence level.[14] Thus, the amended application fails to establish that ARINC's proposed operations are consistent with domestic and international AMSS requirements, and provides insufficient information to fully assess the interference potential from the proposed AMSS system.[15]

B. The *ARINC Ex Parte* Does Not Remedy the Deficiencies in the *ARINC Application*

ARINC argues that the Commission should ignore the AMSS operational requirements set forth in Recommendation ITU-R M.1643. Although Boeing identified a number of inconsistencies in its comments between ARINC's proposed design and the Recommendation, ARINC focuses on only two such deficiencies: the lack of positive control of AES transmissions

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[13] *Id.*

[14] *See generally Boeing Comments and Boeing Further Comments.* For the sake of brevity, Boeing does not repeat here all of the deficiencies of the ARINC proposal identified in its prior comments, and respectfully refers the Commission to those filings.

[15] As discussed *infra*, based on the information provided by ARINC to date and using reasonable assumptions for the data ARINC has not provided, the proposed system could interfere with adjacent satellites up to six degrees away from ARINC's serving satellite.

and its failure to account for pointing error in the calculation of off-axis EIRP.[16] Specifically, ARINC argues that (i) the relevant portions of Recommendation ITU-R M.1643 are not mandatory because they have not been "included by reference in an ITU Radio Regulation," and "[a]s a general principle, the U.S. government has maintained a policy that ITU-R Recommendations are advisory in nature, offering only 'guidance;'"[17] (ii) the language of relevant Working Party 4A and WRC-03 documents should be ignored in interpreting the requirements of Recommendation ITU-R M.1643 with respect to AMSS network control;[18] and (iii) no Radio Regulation or ITU-R Recommendation supports a requirement to include pointing error in calculating the aggregate off-axis EIRP of AES transmissions.[19] ARINC is wrong on all three counts.

1. The Proposed AMSS System Must Comply with Recommendation ITU-R M.1643

While ITU-R Recommendations are by their very nature "advisory" (unless incorporated by reference into the international Radio Regulations), ARINC misconstrues U.S. policy and ignores well-settled Commission precedent expressly imposing compliance with specific ITU-R Recommendations as a condition of licensing. The Commission has often required earth station and space station licensees to operate their networks in accordance with specific ITU-R

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[16] The *ARINC Ex Parte* discusses regulatory matters only and does not supplement the technical showing made by ARINC in support of its application.

[17] *ARINC Ex Parte* at 4, 7-8.

[18] *See id.* at 4-7.

[19] *See id.* at 8-9; *see also* Letter from Carl R. Frank to Marlene H. Dortch, File No. SES-LIC-20030910-01261 (dated March 11, 2004) (*ARINC Ex Parte* transmittal letter).

Recommendations, which are in many cases based on U.S.-supported technical inputs, regardless of whether they have been incorporated by reference into the international Radio Regulations.[20]

Thus, the question of whether ITU-R Recommendations are incorporated by reference into the international Radio Regulations, thereby making them "mandatory" treaty obligations under international law, is not relevant. Regardless of their precise legal status, the Commission routinely finds it useful to expressly condition its authorizations on compliance with specific ITU-R Recommendations. Such regulatory practice not only best ensures compliance of the U.S. licensee with internationally agreed technical and operational requirements, but also embraces requirements that often were developed by technical experts of affected parties in the U.S. National Committee preparatory process for the ITU-R. Such was the case with the development of Recommendation ITU-R M.1643 and the Commission's decision to condition Boeing's AMSS license on compliance with the U.S. input document which formed the basis of this Recommendation.

In the context of the preparations for the 2003 World Radiocommunication Conference, Ku-band FSS satellite interests worked together with Boeing and the Commission to develop AMSS operational and technical requirements for consideration by the ITU-R. The consensus that arose out of the U.S. preparatory process resulted in a United States contribution to Working

[20] *See, e.g.,* AirTouch Satellite Services US, Inc., *Memorandum Opinion and Order*, 2002 FCC LEXIS 2961, DA 01-1420 (Int'l Bur. 2002) at ¶ 4 ("the applicant's proposed interim specifications were in accordance with [Recommendation ITU-R] M.1343[] . . . . The Bureau accordingly granted the application, subject to conditions requiring compliance with the emission limits . . . .); Application of Globalstar, L.P., Order and Authorization, 16 FCC Rcd 13739 (Int'l Bur./OET 2001) at ¶ 16 ("We expect Globalstar's operations to comply with the ITU Recommendation ITU-R S.1340 limits."); Maritel, Inc., *Order*, 16 FCC Rcd 9294 (WTB 2001) at ¶ 14, 15 ("We agree that compliance with ITU requirements is essential, and this waiver is accordingly conditioned on such compliance. . . . This requires that any and all equipment that is approved under authority of this waiver comply with the Part 80-equivalent technical requirements in Recommendation ITU-R M.1084-439 and, where applicable, Recommendations ITU-R M.493.10, ITU-R M.825-3 and ITU-R M.1371").

Party 4A, and Boeing's compliance with the conditions expressed in this paper ultimately became a condition to Boeing's AMSS license.[21] This U.S. input document served as the basis for the FSS protection requirements included in Annex 1, Section A of ITU-R Recommendation M.1643.

Although ITU-R Recommendation M.1643 is not a mandatory requirement under treaty law, compliance with its requirements is a condition of the AMSS license issued to Boeing by the Commission. Moreover, most of the authorizations that Boeing has received from other administrations have mandated compliance with Recommendation ITU-R M.1643. Thus, any suggestion that ARINC should be permitted to operate its proposed AMSS system in derogation of Recommendation ITU-R M.1643 is contrary to clear Commission precedent and the requirements imposed by many nations around the world in the context of AMSS licensing.

2. Recommendation ITU-R M.1643 Requires Positive Control of AES Transmissions

ARINC argues that the network control requirements of Recommendation ITU-R M.1643 are unclear and thus the Commission cannot impose a positive control requirement on its proposed system.[22] Although Boeing believes that the requirements of the Recommendation are clear on their face, any potential uncertainty can be readily clarified by a review of the record of the development of the Recommendation, including the contributions and reports that led to its creation A review of this history reveals that there is no doubt that the international community

[21] The Commission expressly conditioned Boeing's AMSS authorization on compliance with the requirements set forth in the draft Recommendation at the suggestion of the commenting parties to Boeing's application. *See The Boeing Company,* Order and Authorization, 16 FCC Rcd. 22645 (Int'l Bur./OET 2001); *see id.*, ¶ 11. The final recommendation was approved two years later by the 2003 Radiocommunication Assembly (Geneva).

[22] *See ARINC Ex Parte* at 5 ("there are no specifications as to what form such control should be, or what technique should be used. . . . There is nothing in this Recommendation which specifies [a positive control] requirement.").

understands and expects that positive control of AES transmissions be used for all Ku-band AMSS systems.

As discussed in Boeing's Comments in this proceeding, Recommendation ITU-R M.1643 requires Ku-band AMSS systems to employ positive control of AES transmissions.[23] ARINC, however, asks the Commission to focus on a single sentence in Recommendation ITU-R M.1643 to find that positive control of AES transmissions is not mandated by the Recommendation. ARINC claims that the only portion of Recommendation ITU-R M.1643 that addresses network control states that the: "AES should be subject to monitoring and control by an NCMC or equivalent facility."[24] But ARINC ignores the very next sentence of the Recommendation: "AES must be able to receive at least 'enable transmission' and 'disable transmission' commands from the NCMC."[25] Thus, pursuant to the plain language of the Recommendation, the "monitoring and control" of an AES must *at a minimum* include specific commands from the NCMC for the AES to commence (enable) transmission and cease (disable) transmission. Taken together, these two provisions require that the operator of an AMSS network have the ability to positively control every transmission of an AES.[26]

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[23] *See Boeing Comments* at 5-7; *see also Further Boeing Comments* at 7-12.

[24] *See ARINC Ex Parte* at 5 (citing Recommendation ITU-R M.1643, Annex 1, Part A, Section 4).

[25] *See* Recommendation ITU-R M.1643, Annex 1, Part A, Section 4.

[26] Alternative interpretations of this requirement do not withstand scrutiny. For example, the suggestion that the language simply requires that AESs be capable of receiving enable and disable transmission commands, rather than specifically commencing or ceasing transmission on direct command of the NCMC, essentially reads this operational requirement out of the Recommendation. Similarly, the argument that the provision is satisfied if an AES can receive such commands at any point during its operation (*e.g.*, an enable transmission command after it has already commenced transmitting login bursts, or a disable transmission command only after it has already exceeded the off-axis EIRP thresholds) is fundamentally inconsistent with the active "monitoring and control" by the NCMC or the strict control of off-axis EIRP from

ARINC's proposed contention protocol design does not have this capability. For example, rather than receiving an individual enable transmission command, an ARINC AES can commence transmitting even before it is logged in to the network (*i.e.*, considered for network control purposes) at any time after it receives the forward link.[27] Even after an AES is logged in it does not receive individual enable transmission commands, but rather can transmit at will until it receives a "throttle" command.[28] Although ARINC suggests that successful AES login is equivalent to an "enable transmission" command, its AESs are designed to transmit on their own prior to login without being "subject to the monitoring and control of an NCMC or equivalent facility" and transmit on their own even after login without active control. Instead, pursuant to its contention protocol scheme, the ARINC AMSS system exercises purely reactive control over the logged in terminals and only issues a throttle command when the number of simultaneously transmitting AESs in a period of time reaches the point where the off-axis limits will be exceeded 1% of the time. ARINC's network control approach is not consistent with the "essential requirement" of positive control imposed on secondary Ku-band AMSS operations in Recommendation ITU-R M.1643.

The positive control requirement is not only Boeing's understanding from nearly five years of work on Ku-band AMSS technical and regulatory issues, but it is also the clear understanding of the international community. For example, Working Party 4A Document

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secondary AMSS transmissions envisioned by the international community to prevent harmful interference. The only reading that gives full effect to the language of the Recommendation is the "positive control" or "transmit-on-command" approach expressly examined by the ITU-R and upon which Recommendation ITU-R M.1643 and the associated secondary AMSS allocation are based.

[27] *See ARINC Application*, Technical Description at 7.

[28] *See id.* at 10-11, 45. Boeing has highlighted the potential interference risks associated with this approach. *See Boeing Comments* at 7; *Boeing Further Comments* at 13-14.

4A/129, the primary technical study regarding AMSS/FSS sharing requirements, underscores this positive control requirement:

> . . . extensive fault management both on the ground and in the airborne terminals assures that no transmission will occur from any airborne terminal without *positive control* from the ground. . . .[29]
>
> Transmissions from the aircraft are under *positive control* of the NOC. This control includes airborne terminal entry into the network, authorization of transmission frequencies, authorizations to change the transmit power/data rate, and control of the authorized transmit power level . . . .[30]
>
> *Positive control* of airborne terminals is essential to maintaining control of aggregate emissions. Features are included in the system design to ensure that no transmissions take place from an aircraft unless it is under *positive control*.[31]

Similarly, Section 2.4.1.2.1 of the CPM Report for WRC-03 (which adopted the AMSS allocation in the Ku-band) provides:

> 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.[32]

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[29] *See* Working Document Towards Draft CPM Text In Response To Resolution 216 (WRC-2000): System Characteristics and GSO FSS Sharing Study for a Proposed AMSS System in the 14.0-14.5 GHz Band (United States), Doc. 4A/129-E (Apr. 11, 2001) at 2 (emphasis added).

[30] *See id.* at 5 (emphasis added).

[31] *See id.* at 7 (emphasis added).

[32] *See* CPM Report, § 2.4.1.2.1 at 58 (emphasis added). The CPM Report goes on to state that: "AMSS networks will need *rigorous protocols to control the operation of AES to be within*

The explicit discussion in Document 4A/129 and the CPM Report confirms that the international community fully expects that Ku-band AMSS systems employ positive control over all AES transmissions.

3. Recommendation ITU-R M.1643 Requires That Pointing Error and Other Factors to Be Taken Into Account in Calculating Off-Axis EIRP

ARINC also suggests that its proposed system need not account for factors such as pointing error in calculating aggregate off-axis EIRP of AES transmissions because: (i) it is not required by the international Radio Regulations; and (ii) no ITU-R Recommendation supports such a requirement. The first part of ARINC's argument is based on the erroneous notion that the Commission will only require compliance with ITU-R Recommendations that are incorporated by reference into the international Radio Regulations. As discussed above, the Commission routinely conditions licenses on compliance with Recommendations that are not incorporated by reference, including Recommendation ITU-R M.1643 in the case of U.S.-licensed AMSS systems.[33]

The second part of ARINC's argument is equally flawed. Rather than examining the requirements of Recommendation ITU-R M.1643, ARINC cites an ITU-R Recommendation addressing Earth Stations on Board Vessels ("ESVs") to suggest that since ESVs need not account for pointing error in the calculation of off-axis e.i.r.p. but rather must meet a pointing

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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." *See id.* at 58-59 (emphasis added).

[33] *See The Boeing Company,* Order and Authorization, 16 FCC Rcd. 22645 (Int'l Bur./OET 2001).

accuracy requirement of +/- 0.2 degrees, ARINC's proposed AMSS system should only be required to comply with this latter requirement.[34] Not only is the ESV Recommendation irrelevant to this AMSS application proceeding, but reference to Recommendation ITU-R M.1643 confirms that ARINC must take antenna pointing error and other technical and operational factors into account in calculating the off-axis EIRP generated by AES transmissions. Annex 1, Part A, Section 2 of Recommendation ITU-R M.1643 provides:

> 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 . . . .

Thus, Recommendation ITU-R M.1643 plainly requires AMSS systems to account for antenna mispointing in the calculation of off-axis EIRP.

ARINC has not provided such information in its application, as amended, and the Commission should defer acting on this application until this data is provided in sufficient detail to determine whether the proposed system will interfere with other FSS networks. As demonstrated in the attached Technical Appendix, Boeing's analysis indicates that there are serious questions as to whether ARINC's proposed AMSS system can operate in such a manner.

C. Boeing's Independent Analysis Confirms that the ARINC AMSS System Poses a Significant Risk of Interference to Adjacent FSS Satellites

In light of ARINC's failure to provide the necessary support for its assertions that co-frequency operations would not be adversely affected by its AMSS operations in the Ku-band,

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[34] *See ARINC Ex Parte* at 9.

Boeing conducted an interference analysis of the proposed system using a Monte Carlo simulation similar to the one used in ITU-R WP 4A studies leading up to the development of Recommendation ITU-R M.1643. The methodology and results of this analysis are included in the attached Technical Appendix. They show that if the proposed AMSS system were to operate as described in the ARINC application, it poses a significant risk of interference to at least four adjacent FSS satellites.

Properly designed AMSS systems operating under positive control and accounting for the effects of pointing error, EIRP variation, and antenna pattern variation in the aggregation of off-axis EIRP spectral density were shown in ITU-R studies to be able to meet the stringent off-axis levels contained in the Commission's rules minus 1 dB with a 99.99% probability.[35] These studies were instrumental in satisfying the FSS community that co-frequency AMSS operations in the Ku-band would not cause harmful interference to adjacent FSS satellites.[36] In contrast, as indicated above, ARINC is seeking FCC authority to operate a Ku-Band AMSS system without using positive power control and without properly taking into account pointing errors and other factors affecting the calculation of off-axis EIRP.

The simulation reported in the attached Technical Appendix evaluates the off-axis EIRP of the proposed ARINC system by generating 100,000 Monte Carlo trials of the aggregate EIRP spectral density. Each trial considers a pool of logged-in AESs and determines how many of the AESs are transmitting simultaneously based on an assumed AES duty cycle. The simulation then applies pointing and power control errors to the off-axis EIRP of each transmitting AES and adds each off-axis EIRP to determine the aggregate level for the trial. When all of the

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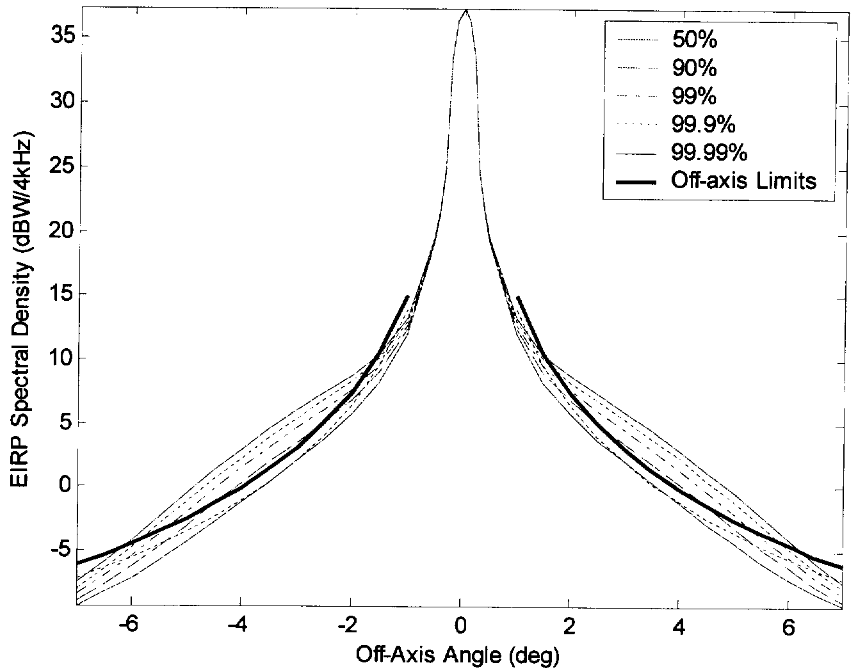
[35] *See* Technical Appendix at 1.

[36] *See id.*

transmitting AESs have been taken into account, the aggregate EIRP spectral density is multiplied by an appropriate factor to account for errors not adequately taken into account by ARINC. The simulation then adds the off-axis EIRP of the forward link, which operates co-frequency with the return link, to the aggregate and determines the expected levels of worst-case off-axis EIRP from the proposed AMSS system.

The results of all 100,000 trials were then used to compute off-axis EIRP probability envelopes for the proposed ARINC system, which is compared to the off-axis EIRP levels set forth in the Commission's rules and the work performed in WP 4A. As indicated in the following chart, ARINC's 99.99% EIRP envelope *exceeds* the off-axis levels set forth in the Rules by 3.1 dB. This compares to the WP 4A studies where the 99.99% EIRP envelope was found to be 1 dB *below* these levels for a properly designed AMSS system. The proposed ARINC system would exceed these levels between 1.5 degrees and 6.2 degrees off-axis and at certain points the probability of exceeding the levels reaches 10%.[37]

[37] *See id.* at 8-9. ARINC's proposed operations at 103° W.L. would cause the area of exceedance to include at least four adjacent Ku-Band satellites: Galaxy 4R at 99° W.L., AMC 4 4R at 101° W.L. (where Boeing has operations), AMC 2 4R at 105° W.L., and Anik F1 at 107.1° W.L.



ARINC Off-Axis EIRP Probability Envelop

As reflected in this analysis, the proposed AMSS system poses a significant risk to operations of adjacent FSS satellites. Factors that ARINC does not adequately account for include:

- Pointing error,
- EIRP variations due to closed loop power control and reverse calculation error,
- Contributions of the forward uplink signal to the aggregate emissions received at the geostationary arc, and
- The 99.99% error envelope considered in previous AMSS studies.

ARINC should be required to account for these and other factors set forth in Recommendation ITU-R M.1643, including positive control of AES transmissions.

II. CONCLUSION

The Commission should ensure that the proposed ARINC system is implemented consistent with the Commission's AMSS licensing precedent and Recommendation ITU-R M.1643. ARINC has not provided sufficient information to conclude that its proposed system is consistent with the Recommendation and can operate in a manner that fully protects co-frequency users of the Ku-band. Accordingly, the Commission should defer action on the proposed AMSS application until such time as ARINC provides the information necessary to rule favorably on its application.

Respectfully submitted,

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CERTIFICATE OF SERVICE

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TECHNICAL APPENDIX

A Frequency Sharing Analysis of the ARINC AMSS System With Respect to the Fixed Satellite Service

Summary

This analysis examines the proposed ARINC Inc. ("ARINC") Aeronautical Mobile-Satellite Service ("AMSS") system with a Monte Carlo simulation similar to the one used in ITU-R Working Party 4A during the Ku-band AMSS allocation studies and the development of Recommendation ITU-R M.1643. The results show that the proposed system poses a significant interference risk to operations of adjacent Fixed-Satellite Service ("FSS") satellites by exceeding the off-axis levels set forth in the Commission's rules by up to 3.1 dB between 1.5 degrees and 6.2 degrees off-axis for as much as 10% of the time.

Background

When ITU-R Working Party 4A recently considered expanding the existing MSS allocation in the Ku-band to include AMSS, the United States presented Monte Carlo simulations demonstrating that an AMSS system operating under positive control and accounting for the effects of pointing error, EIRP variation, and antenna pattern variation in the aggregation of off-axis EIRP spectral density, could meet the stringent U.S. off-axis levels minus 1 dB with a 99.99% probability.[1] An example of the results from this study is shown in Figure 1. This study was cited in the CPM Report to the 2003 World Radiocommunication Conference ("WRC-03") and was instrumental in satisfying the FSS community that co-frequency AMSS operations in the Ku-band would not cause harmful interference to adjacent satellites.[2]

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[1] *See* Working Document Towards Draft CPM Text In Response To Resolution 216 (WRC-2000): System Characteristics and GSO FSS Sharing Study for a Proposed AMSS System in the 14.0-14.5 GHz Band (United States), Doc. 4A/129-E (Apr. 11, 2001).

[2] *See* Conference Preparatory Meeting Report to WRC-03, § 2.4.1.2.1 at 58-59 ("CPM Report").

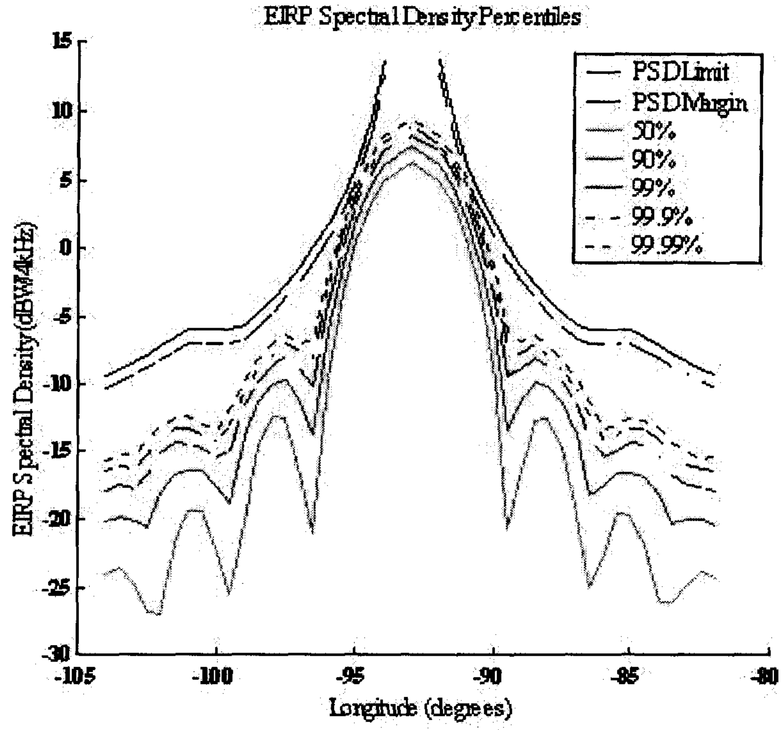

Figure 1. US Monte Carlo Study Results Presented in WP 4A

Based on these studies, the United States also proposed a draft new recommendation ("DNR") to capture the fundamental technical and operational requirements for Ku-band AMSS systems, including essential requirements related to the protection of FSS networks. The requirements for protection of FSS networks included operating under positive control and accounting for pointing error, EIRP variation, and antenna pattern variation in the aggregation of off-axis EIRP spectral density.[3] This DNR eventually became Recommendation ITU-R M.1643, and the FSS protection requirements are included in Annex 1, Section A of the Recommendation. The FCC has made compliance with these requirements a precondition for licensing the first U.S. Ku-band AMSS system and reaffirmed them in subsequent modifications to that system.[4]

ARINC is seeking FCC authority to operate a Ku-Band AMSS system, but its application contained numerous technical errors (some values were off by more than a factor of a thousand) and a lack of detail demonstrating compliance with Recommendation ITU-R M.1643, including credible pointing error data and EIRP variation numbers.[5] Boeing's initial Comments on the ARINC application pointed out many of these errors and

[3] *See* Draft New Recommendation on Operation and Control of AMSS Networks in the 14.0-14.5 GHz Band Relative to FSS Networks (United States), Doc. 4A/278-E (26 Sept. 2001).

[4] *See The Boeing Company,* Order and Authorization, 16 FCC Rcd. 22645 (Int'l Bur./OET 2001) and subsequent modification authorizations.

[5] *See generally* Comments of the Boeing Company, File No. SES-LIC-20030910-01261, Call Sign E030205 (filed November 14, 2003) ("Boeing Comments").

While ARINC subsequently corrected some of these errors and supplied a limited amount of the requested data, it did not provide sufficient information to demonstrate compliance with all of the requirements contained in Recommendation ITU-R M.1643.[6] In Boeing's Further Comments it supplied reasonable estimates of the ARINC pointing errors and EIRP variations and showed that these values would make compliance with Recommendation ITU-R M.1643 very difficult, if not impossible.[7] In addition, Boeing suggested that ARINC replicate the type of comprehensive analysis performed in WP 4A to demonstrate that its proposed AMSS network would not interfere with the FSS.[8] A subsequent *ex parte* filed by ARINC did not provide the necessary data or analysis, but rather asserted that the ITU recommendations are not mandatory and therefore ARINC was not required to comply with Recommendation ITU-R M.1643.[9]

ARINC's failure to demonstrate compliance with Recommendation ITU-R M.1643 is sufficient reason alone to defer action on the pending application. In addition, as demonstrated in the following analysis, the proposed AMSS system would pose a risk of interference to adjacent FSS satellites if operated as indicated in ARINC's underlying application.

Monte Carlo Simulation Structure

The simulation evaluates the off-axis EIRP of the proposed ARINC system by generating 100,000 Monte Carlo trials of the aggregate EIRP spectral density. Each trial considers a pool of logged-in Aircraft Earth Stations ("AESs") and determines how many of the AESs are transmitting simultaneously based on an assumed AES duty cycle. The simulation then applies pointing and power control errors to the off-axis EIRP of each transmitting AES and adds each off-axis EIRP to determine the aggregate level for the trial. When all of the transmitting AESs have been taken into account, the aggregate EIRP spectral density is multiplied by an appropriate factor to account for errors introduced by ARINC's reverse calculation approach. Finally, the simulation adds the off-axis EIRP of the forward link, which operates co-frequency with the return link, to the aggregate and stores the results.

The results of all 100,000 trials are then used to compute off-axis EIRP probability envelopes for the proposed ARINC system, which is compared to the off-axis EIRP levels set forth in the FCC's rules and the work performed in WP 4A. To simplify the

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[6] *See generally* Response of ARINC Inc., File No. SES-LIC-20030910-01261, Call Sign E030205 (filed November 28, 2003) ("ARINC Response"). ARINC's associated application amendment incorporated these corrections in the application's Technical Appendix.

[7] *See* Further Comments of the Boeing Company, File No. SES-LIC-20030910-01261, Call Sign E030205 (filed December 18, 2003) ("Boeing Further Comments") at 12-20.

[8] *See id.* at 20.

[9] *See generally* Written Ex Parte Presentation, File No. SES-LIC-20030910-01261 (filed March 11, 2004) (Assessment of Comments on the ARINC Proposed Aeronautical Mobile Satellite Service (AMSS) In The 14.0-14.5 GHz Band (SKYLINK)) ("*ARINC Ex Parte*").

simulation, the aggregate levels are only computed over the first 7 degrees off-axis where interference is most likely to occur. Each of the components of the simulation is described in greater detail below.

Antenna Pattern

The ARINC antenna pattern is modeled as being parabolic with a 3 dB beam width of 4.8 degrees and a peak gain of 30.96 dBi.[10] Within 7 degrees off axis this model has proven to be sufficiently accurate for purposes of the simulation.

Contention Protocol Access

Contention protocols add a source of off-axis EIRP variation that was not considered by WP 4A, and indeed are inconsistent with the positive control requirement considered by the ITU-R and included in Recommendation ITU-R M.1643. Assuming such an approach is permissible, however, all factors affecting the aggregate off-axis EIRP must be accounted for in the aggregation pursuant to Recommendation ITU-R M.1643 Annex 1, Part A, Item 2.

Three basic parameters are necessary to simulate the performance of the ARINC contention protocol design. These are:

- The number of aircraft logged into the system
- The operational duty cycle of each AES
- The EIRP spectral density of each AES

ARINC's contention protocol design allows a pool of AESs to log in and then transmit at will. The proposed ARINC system only sends a throttle command when the probability of exceeding an aggregate input power of -24.25 dBW/4kHz reaches 1%.[11] This represents the fully loaded condition for the ARINC system. ARINC did not provide any duty cycle information, however, so it is necessary to make estimates of this factor. ARINC has stated that 214 logged-in aircraft will support 38 simultaneous accesses at 32 kbps.[12] Using these figures, and assuming a Poisson process for AES accesses, Boeing calculated a corresponding duty cycle of 12.25% per AES.

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[10] *See* ARINC Application, Technical Description at 25 (AES transmit gain).

[11] *See* ARINC Response, Technical Exhibit at 2.

[12] *See* ARINC Application, Technical Description at 45 and 48. Boeing pointed out in its Further Comments at 17 that the number of simultaneous accesses at 32 kbps would need to be reduced from 38 simultaneous accesses to 28 simultaneous accesses if the input power at Bangor, Maine is considered, as ARINC says it does in its Response to Boeing's initial Comments. *See* ARINC Response at 8-9.

The simulation assesses the minimum number of simultaneous accesses that will fully load a sub-band in order to determine the maximum off-axis EIRP.[13] For this simulation, the minimum number of simultaneous accesses that will fully load the system is assumed to be seven, which occurs when a single 13.824 MHz return link sub-band is occupied by 128 kbps AESs. The resulting individual input power density is -32.59 dBW/4kHz.[14] Assuming the maximum duty cycle remains the same at 12.25%, seven simultaneous accesses will occur 1% of the time for a pool of 25 logged-in AESs.

In order to test these assumptions, Boeing performed a simulation to duplicate the off-axis EIRP performance of the proposed ARINC system as described in the ARINC Response. Figure 2, below, shows the results of this simulation. The 99% off-axis EIRP envelope remains 1 dB below the off-axis levels contained in the FCC's rules when all sources of off-axis EIRP variation except contention protocol access are set to zero, as assumed by ARINC. (Boeing disputes that it is appropriate to assume away such sources of off-axis EIRP variation.) This validates that Boeing's assumptions regarding duty cycles and numbers of logged-in AESs are reasonable in the absence of data provided by ARINC.

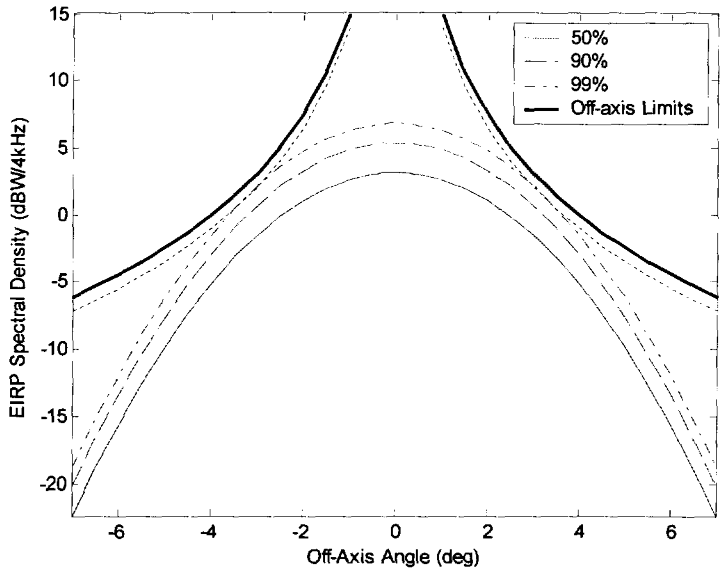

Figure 2. 99% Off-axis EIRP Considering Only Contention Protocol Access

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[13] The effect of errors that apply to the individual AES off-axis EIRP, such as pointing errors, is reduced by the statistical aggregation of many terminals. Therefore, the effect of these errors on the aggregate is the greatest when the aggregate is the result of a few high-powered users rather than many low-power users.

[14] *See* ARINC Response at 10 (minimum bandwidth of a 128 kbps signal). The input power is based on the antenna flange power density for a 128 kbps, 28.8 MHz signal from Bangor, Maine. *See* ARINC Application, Technical Description at 26. The 28.8 MHz value has been multiplied by 28.8/13.824 to obtain the 13.824 MHz value.

Pointing Error

ARINC claimed a pointing accuracy of 0.1 degrees rms in its initial Application.[15] Boeing pointed out that ARINC had not considered the largest factors that contribute to pointing error and asked ARINC to provide additional data.[16] ARINC's Response acknowledged these factors but did not provided revised pointing accuracies.[17] As a result, Boeing has made its own estimates of pointing accuracy based on the technologies described by ARINC -- 0.59 degrees in azimuth and 0.38 degrees in elevation -- and used them in this simulation.[18]

Closed Loop Power Control Accuracy

ARINC proposes to employ a closed loop power control system to maintain Eb/No at the Ground Earth Station ("GES") within a target range.[19] The GES issues power control commands to the AES to adjust its power in 0.25 dB increments.[20] However, all such closed loop power control systems have a control envelope that is greater than the minimum EIRP increment as a result of such factors as control loop latency, measurement noise, and short term disturbances. ARINC did not provide any additional information regarding its power control loop, and therefore Boeing used a reasonable estimate for the closed loop power control accuracy of 0.25 dB rms.

Reverse Calculation EIRP Control Error

ARINC treats all AESs as if they are transmitting from a semi-worst case location of Bangor, Maine when calculating its aggregate off-axis EIRP.[21] The transmit EIRP required from Bangor for a given data rate is inferred from a link budget using a "reverse calculation" methodology.[22] ARINC also employs a ground transmitter to calibrate the link budget.[23] As Boeing has pointed out, this technique is subject to numerous errors, such as the uncertainty in the calibration terminal EIRP and knowledge of the satellite

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[15] *See* ARINC Application, Technical Description at 16.

[16] *See* Boeing Comments at 9.

[17] *See* ARINC Response, Technical Exhibit at 4.

[18] *See* Boeing Further Comments at 14-15.

[19] *See* ARINC Application, Technical Description at 8-9.

[20] *See id.* at 45.

[21] *See* ARINC Response at 8-9.

[22] *See* ARINC Application, Technical Description at 9. *See* Boeing's discussion of this technique in its Comments at 10.

[23] *See* ARINC Response, Technical Exhibit at 4-5.

gain map, that will cause the entire aggregate to be off by a significant margin.[24] ARINC has not provided a tolerance buildup for this calculation method. Accordingly, Boeing used a 0.48 dB rms error for all of the error components that applied to the aggregate based upon the work of WP 4A, which used a very similar reverse calculation methodology with calibration.[25]

Forward Uplink Off-axis EIRP

ARINC employs a Paired Carrier Multiple Access ("PCMA") scheme whereby the forward and return links operate co-frequency in the same transponder.[26] Boeing has commented that the off-axis EIRP of the forward link should be accounted for in the aggregate off-axis EIRP.[27] ARINC has indicated that it intends to use a 4.5 m antenna that is compliant with Section 25.209 of the Rules that is authorized for an input power of -17.4 dBW/4kHz.[28] For the purpose of this simulation the forward link antenna is treated as having a peak gain of 54.7 dBi that rolls off parabolicly to +/- 0.5 degrees off-axis. Beyond +/- 0.5 degrees the antenna is treated as rolling off in accordance with Section 25.209 (*i.e.,* 29 – 25 log(theta) dBi), as is shown in Figure 3.

[24] *See* Boeing Further Comments at 18.

[25] *See* WP 4A Doc. 4A/129-E at 18.

[26] *See* ARINC Application, Technical Description at 2, 17-18.

[27] *See* Boeing Comments at 11; Boeing Further Comments at 19.

[28] *See* ARINC Response, Technical Exhibit at 4.

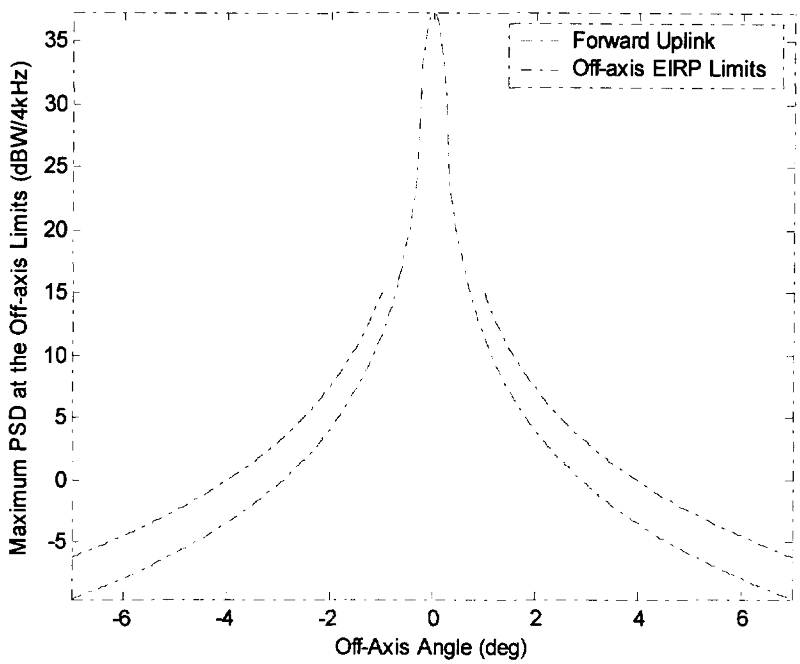

Figure 3. Forward Uplink Off-axis EIRP

Simulation Results

Figure 4 shows the results for the proposed ARINC system of 100,000 trials considering all of the contributions to aggregate off-axis EIRP described above, including the forward uplink. The ARINC 99.99% EIRP envelope *exceeds* the off-axis levels set forth in the Rules by 3.1 dB. This compares to the WP 4A studies where the 99.99% EIRP envelope was found to be 1 dB *below* these levels. The proposed ARINC system exceeds the levels between 1.5 degrees and 6.2 degrees off-axis and at certain points in this region the probability of exceeding the levels reaches 10%.[29] Considering ARINC's proposed operations at 103° W.L., the area of exceedance includes at least four adjacent Ku-Band satellites: Galaxy 4R at 99° W.L., AMC 4 4R at 101° W.L. (where Boeing has operations), AMC 2 4R at 105° W.L., and Anik F1 at 107.1° W.L. The area of exceedance falls only a few tenths of a degree short of the Intelsat Americas 5 at 97° W.L.

[29] Even if the forward uplink could be totally neglected, which is unlikely, the proposed ARINC system would still exceed the off-axis levels by up to 2.1 dB over a range of 2.2 degrees to 5.2 degrees off-axis.

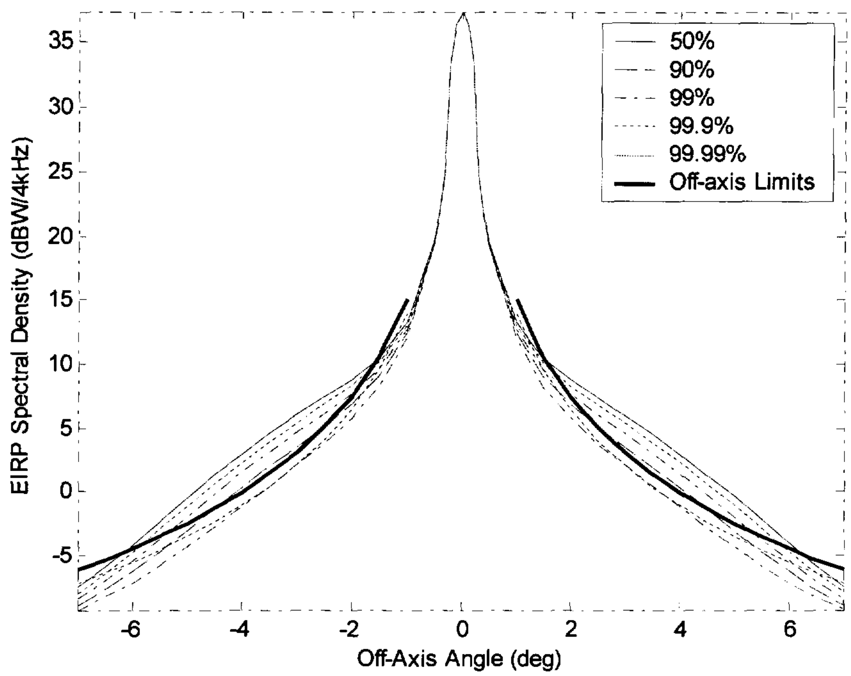

Figure 4. ARINC Off-Axis EIRP Probability Envelopes

Conclusions

Because the proposed ARINC system would operate in a manner that is not compliant with Recommendation ITU-R M.1643 (*e.g.*, its operation does not account for all of the factors that affect off-axis EIRP) it poses a risk of interfering with the operations of adjacent FSS satellites. Factors that ARINC does not adequately account for include:

- Pointing error,
- EIRP variations due to closed loop power control and reverse calculation error,
- Contributions of the forward uplink signal to the aggregate emissions received at the geostationary arc, and
- The 99.99% error envelope considered in previous AMSS studies.

As a result, the proposed ARINC system will exceed the off-axis levels by up to 3.1 dB between 1.5 degrees and 6.2 degrees off-axis as much as 10% of the time.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this pleading, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this pleading, and that it is complete and accurate to the best of my knowledge and belief.

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