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Via HAND DELIVERY

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Written Ex Parte Presentation
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 Nos. SES-AMD-20031223-01860 and SES-LIC-20030910-0126, Call Sign E030205

Dear Ms. Dortch:

The Boeing Company ("Boeing") hereby submits its evaluation of the most recent engineering and operational information provided by ARINC Incorporated ("ARINC") in support of its SKYLink Aeronautical Mobile-Satellite Service ("AMSS") system application.[1] In its submission, ARINC provided additional information regarding the mechanisms it proposes for limiting the number of simultaneous accesses by aircraft earth stations ("AESs") in the SKYLink system to demonstrate compliance with the off-axis e.i.r.p. mask associated with routinely licensed VSAT terminals. As set forth in the attached Technical Analysis, however, serious questions remain regarding the interference potential of the SKYLink system.

In particular, the control mechanisms of the SKYLink system are woefully insufficient to effectively prevent interference into adjacent satellites with an adequate confidence level. As ARINC itself confirms, during peak or "worst case" conditions the SKYLink system's congestion controller will only attempt to limit AES transmissions when the system's compliance level drops to 99%.[2] Even assuming compliance with such a low interference

[1] Letter from Carl R. Frank to Marlene H. Dortch, File Nos. SES-LIC-20030910-01261 and SES-AMD-20031223-01860 (filed June 3, 2004).

[2] In contrast, Boeing's licensed AMSS system is designed to control interference with a 99.99% confidence level during peak or worst-case conditions.

control threshold level would be permissible in the context of Ku-band AMSS licensing, it is not at all clear whether the SKYLink system can actually meet this threshold. In addition to the issues raised by Boeing in its prior filings, ARINC's ability to satisfy its claimed compliance level rests largely on questionable traffic assumptions and unexplained approaches to traffic management. Furthermore, there are additional shortcomings in ARINC's analysis (*e.g.*, failure to accurately account for AES pointing error, e.i.r.p. variation, AES operating link margins, forward uplink off-axis e.i.r.p., etc.) that have not been adequately addressed.

Boeing believes that these and other outstanding technical issues regarding the SKYLink system's interference potential must be fully resolved before the system can be licensed. If the Commission concludes otherwise, however, at a minimum ARINC's license must be conditioned on compliance with internationally adopted AMSS operational standards (Recommendation ITU-R M.1643) and verification of all SKYLink system operational and control parameters prior to commencement of commercial operations, as was required of Boeing in the context of licensing the Connexion by Boeing[SM] system's transmit-receive operations.[3] With respect to system performance verification, the Commission should ensure that this includes a full analysis of those operational and control parameters noted by Boeing that may affect the interference potential of the SKYLink system.

Finally, Boeing would note that if the Commission authorizes the SKYLink system as presently designed, it is essentially "lowering the bar" with respect to the protection afforded by Ku-band AMSS systems to other users of the band. In particular, permitting the use of contention protocols rather than requiring positive control of AES transmissions, and lowering the interference control threshold from the previously approved level of 99.99% under worst-case conditions to 99%, will necessarily increase the potential for interference into Ku-band FSS operations. Authorizing AMSS operations pursuant to less stringent standards also may have significant unintended consequences. For example, because the international community adopted the secondary Ku-band AMSS allocation at WRC-03 based on technical studies demonstrating a substantially higher level of protection, the Commission's action could undermine international support for Ku-band AMSS operations and hinder AMSS licensing efforts abroad. Furthermore, given the precedential value of allowing a Ku-band AMSS system to operate using less restrictive interference protection criteria, the Commission should expect

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[3] *See* The Boeing Company Application for Blanket Authority to Operate Up to Eight Hundred Technically Identical Transmit and Receive Mobile Earth Stations Aboard Aircraft in the 14.0-14.5 GHz and11.7-12.2 GHz Frequency Bands, *Order and Authorization*, File No. SES-LIC-20001204-02300, DA 01-3308 (rel. Dec. 21, 2001) at ¶ 19(h)(5).

other Ku-band AMSS systems – including potentially Connexion by Boeing[SM] – to seek authority to operate according to these less stringent standards. Thus, the Commission should remain mindful of the potential impact of its licensing decision in this proceeding on future Ku-band AMSS operations in the United States and around the world.

Any questions regarding this matter may be directed to the undersigned.

Respectfully submitted,

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TECHNICAL ANALYSIS

This Technical Analysis sets forth The Boeing Company's ("Boeing") evaluation of the most recent engineering and operational information provided by ARINC Incorporated ("ARINC") in support of its SKYLink Aeronautical Mobile-Satellite Service ("AMSS") system application.[1] As set forth herein, serious questions still remain regarding the interference potential of the SKYLink system to other satellite systems and services operating in the Ku-band.[2] While ARINC has made additional claims regarding mechanisms it proposes for limiting the number of simultaneous accesses by aircraft earth stations ("AESs") in the SKYLink system to demonstrate compliance with the off-axis e.i.r.p. mask associated with routinely licensed VSAT terminals,[3] those claims are not supported by the record and are internally inconsistent.

1. Uncertain Off-Axis E.I.R.P. Compliance

In the SKYLink application, ARINC described, in summary fashion, the levels to which it will control off-axis interference as follows:

> Aggregate EIRP density is managed by the NMS by implementing return link power control and by ensuring that the total number of simultaneous transmission by [AESs] will not exceed the maximum routinely authorized EIRP density more than 0.001% of the time. The number of simultaneous transmissions is managed using a congestion control algorithm. . . .
>
> Congestion is controlled depending on the number of users logged into the system. When the number of logged-in users exceeds the capacity, the congestion control algorithm monitors the aggregate number of simultaneous accesses, and maintains access to a level such that the peak number of simultaneous accesses is less than the capacity 99% of the time.[4]

ARINC subsequently confirmed these values in response to Boeing's initial comments:

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[1] Letter from Carl R. Frank to Marlene H. Dortch, File Nos. SES-LIC-20030910-01261 and SES-AMD-20031223-01860 (filed June 3, 2004) ("ARINC Response").

[2] Supplemental Comments of The Boeing Company, File Nos. SES-LIC-20030910-01261 and SES-AMD-20031223-01860 (filed May 21, 2004) ("Boeing Supplemental Comments"). In addition to the issues identified in this submission, Boeing has raised numerous technical questions in its prior filings regarding the interference potential of the SKYLink system, which are hereby incorporated by reference.

[3] For the purpose of this discussion the FCC mask will be defined as the off-axis EIRP spectral density generated by an input power density of -14 dBW/4kHz from Rule 25.134(b) into a Rule 25.209(a) compliant antenna.

[4] SKYLink Application, File No. SES-LIC-20030910-01261 and SES-AMD-20031223-01860, Technical Supplement at 10-11.

> "The SKYLink NMS actively manages the probability of exceeding the off-axis eirp density to be no greater than 1%; the actual probability of exceeding the off-axis eirp density, however, is much less than this limit (*i.e.*, <0.001%) based on analysis and simulations of the expected traffic."[5]

The SKYLink application and associated filings submitted in response to Boeing's technical inquiries reveal only two mechanisms for controlling the aggregate emissions of AESs in the SKYLink system:[6]

1. A bulletin board mechanism that limits the number of AESs that may attempt to log in at one time by limiting the frequency and time slots at which log in attempts may be made (which also presumably controls the total number of AESs that may be logged in at one time).

2. A congestion control mechanism that acts once the number of simultaneous transmissions from logged in AES reaches a 1% probability of exceeding the off-axis e.i.r.p. mask.

Thus, ARINC states that it intends to use a congestion control algorithm to limit the number of simultaneous AES transmissions based on an off-axis e.i.r.p. compliance level of 99%.

ARINC attempts to soften the fact that it exercises control only at the 99% compliance level, rather than its claimed 99.999% level, by referring to an undefined "preset threshold" in the discussion entitled "ARINC's Congestion Control Software *Further Reduces* SKYLink[SM] Emissions."[7] However, rather than "further reducing"

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[5] Response of ARINC Incorporated, File No. SES-LIC-20030910-01261 (filed Nov. 28, 2003), Exh. 1 (SKYLink Technical Exhibit) at 2. The difference between the 1% non-compliance level and the claimed 0.001% level appears to be based on ARINC's traffic assumptions and related SKYLink system design features (*e.g.*, transponder loading, traffic patterns, contention protocol settings, etc.). ARINC Response, Exh. 1 at 10. As discussed herein, not only are ARINC's assumptions questionable, but they also fail to account for increased loading of available transponder capacity as system traffic grows. Furthermore, a major use of transponder capacity -- the ARINC uplink from the land earth station -- is not considered by ARINC in its evaluation of the probability of interference and could substantially skew its probability calculation.

[6] ARINC's latest filing also refers to time slotting of bursts for logged in terminals. ARINC Response, Exh. 1 at 6 ("Considering only those AES already "logged-in" to SKYLink[SM], each AES may transmit brief, packetized bursts *within a time period specified by the bulletin board message to the AES*.") (emphasis added). There does not appear to be any other reference in the application or related materials to time slotting for bursts from already logged in terminals (although there is reference to time slotting for AESs initially logging in). This previously undisclosed time slotting may be an additional control mechanism. If so, ARINC should fully explain how it works (*e.g.*, what factors are monitored and how, what control thresholds are used, and what actions are taken once the control threshold is reached). If not, ARINC should explain what the above-quoted statement actually means.

[7] *See id.* at 9 (Section 1.5) (emphasis added).

SKYLink emissions as suggested by ARINC, the congestion controller simply attempts to limit the substantial *increases* in interference caused by SKYLink AES transmissions during peak periods -- namely, when the probability of exceeding the FCC's off-axis e.i.r.p. mask is one thousand times greater than ARINC's claimed 99.999% performance level. ARINC elsewhere specifies the 99% compliance threshold for control, but states that this is merely an initial setting.[8] It is not clear, however, whether ARINC seeks to increase or decrease this initial value, or why it is not set to ARINC's claimed compliance level of 99.999%.[9]

There are also substantial questions as to whether ARINC's congestion control mechanism could even meet an interference limit to adjacent satellites with a 1% probability.[10] For example, ARINC has never given a clear description of how pointing errors, e.i.r.p. variation, and the forward uplink off-axis e.i.r.p. contribution would be accounted for in the aggregate off-axis e.i.r.p. Boeing has shown that not accounting for these factors will result in an off-axis e.i.r.p. level that exceeds the FCC mask up to 10% of the time, when the ARINC system is in the congestion control regime.[11]

Even assuming that the congestion control mechanism would work as stated, it still only acts to limit AES transmissions when the interference caused by the SKYLink system exceeds the FCC's off-axis e.i.r.p. mask for 1% of the time. The ability to reach the 0.001% level appears to rest entirely on the SKYLink system's expected user traffic. If traffic does not conform to ARINC's preconceived model, the sole protection from interference is the congestion control mechanism. However, as set forth in Section 3, below, there are numerous flaws in ARINC's traffic assumptions. In addition, since there are no mechanisms *to enforce* the expected user traffic, the SKYLink system will spend an indeterminate amount of time in the congestion control regime (where the off-axis e.i.r.p. mask is exceeded 1% of the time).

2. Lack of Off-Axis E.I.R.P. Monitoring and Management

ARINC claims in its most recent filing that "[t]he SKYLink system will manage AMSS traffic to ensure that the aggregate e.i.r.p. does not exceed the mask set forth in Part 25 more than 0.001 percent of the time,"[12] and that it "monitors and controls interference levels directly, dynamically and proactively in real-time to ensure an

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[8] *Id.* at 10.

[9] The validity of ARINC's claimed overall compliance level is also unclear. Spreading the time window of data used to compute compliance with the off-axis e.i.r.p. mask lowers the net probability of exceedance because it dilutes the effects of transmission bursts with quiescent times. It is not clear what ARINC uses as a data window for calculating its exceedance nor what time window the SKYLink system's off-axis e.i.r.p. management algorithm uses for calculating its rolling window of probability.

[10] *See generally* Boeing Supplemental Comments.

[11] *See id.* at 14-16 and Technical Appendix.

[12] ARINC Response, Exh. 1 at 1.

extraordinarily low potential for what is essentially undetectable co-frequency interference."[13] However, there do not appear to be any "dynamic," "proactive" or "real-time" system management mechanisms other than the congestion controller that ARINC has previously described (and even this device only reacts after a 250 millisecond interval). In fact, Section 1.3 of the ARINC Response (which is titled "SKYLink Continuously Monitors the Number of Simultaneously Transmitting AES in Order to Stay Below the Mask"), is actually devoted to describing the assumed user traffic for ARINC's Monte Carlo simulation.[14] No monitoring or control mechanism is described in the section, nor is there a description of how any proposed mechanism would ensure that the SKYLink system meets the FCC off-axis e.i.r.p. mask.[15]

Similarly, Section 1.4 of the ARINC Response (which is titled "SKYLink Actively Manages the Overall Probability of Exceeding the VSAT Mask to Stay Below 0.001 Percent") is actually devoted to the joint probability of the expected user traffic and the probability of exceeding the FCC mask for a given number of simultaneous transmissions.[16] Again, aside from the congestion management system, the only "management" described in this section is a statement that ARINC will add satellite transponders as the number of AESs grow to maintain the probability level of exceeding the off-axis e.i.r.p. mask.[17] Since there is no active management or control system described that ensures that the users will behave as anticipated, the claim that ARINC meets the 0.001% level rests entirely on expected user traffic.

3. Questionable Traffic Assumptions and Traffic Management Approaches

ARINC's claim that its system will meet the aggregate off-axis e.i.r.p. levels is based on a Monte Carlo simulation of its users' traffic patterns that relies on faulty traffic assumptions. While Monte Carlo simulations, along with other statistical analysis tools like the Norros equation for estimating Internet traffic patterns, may be appropriate for guiding operators in sizing a system, they have no applicability for real-time control unless the system actually *enforces* the statistical patterns used in the analysis. Because ARINC's Monte Carlo simulation assumes random traffic patterns, rather than real world traffic patterns that are non-random and also not predictable, its results are inherently unreliable.

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[13] *Id.* at 10.

[14] *Id.* at 6-7.

[15] The only statement in the section that appears to be related to the title is that "[a]s demand grows, ARINC will expand its leased Ku-band capacity and assign AES to multiple transponders." *Id.* at 6. While this might be loosely construed as a commitment to monitoring and control, given that acquiring new transponders takes weeks or months, there is nothing about this approach that is a "proactive," "dynamic" or "real-time" control mechanism.

[16] *Id.* at 7-8.

[17] *Id.* at 8.

The packet stream coming from a user is neither predictable nor random. It is dependent on what the user wants to do moment to moment as well as the protocols, the applications he or she is using and how those protocols interact with network events such as delay and congestion. Packet stream characteristics also will change in the future as new protocols are invented, new applications are developed and users gain experience on system performance.

At one time, the data networking community believed that as user numbers increased, statistical multiplexing would result in a relatively constant average demand and therefore data pipes could be worked to high average capacities. This theory has been abandoned because it has proven to be false. Instead, aggregate Internet traffic is "bursty" (*i.e.*, with numerous peaks and dips in traffic flows) because of the way the protocols work. These bursts are not caused by single packets being sent by multiple users but by groups of packets being sent by multiple users, and these groups of packets overlap in time.

Real world events such as a weather emergency, a stock market plunge or an election also prompt individuals to seek information or exchange information at the same time. With multiple users on an airplane, events such as reaching altitude, meals and descents further tend to synchronize bandwidth use. Additionally, network events such as a router failure or congestion on a trunk line cause LAN activities to synchronize. For example, congestion occurs when LAN traffic bursts exceed the RF link rate, causing queues to form in the router and then the router starts dropping packets. If a user is transferring a large file, the behavior of Transmission Control Protocol ("TCP") is to drive the transmission rate up to the point where the link is congested and packets are dropped. TCP will then slow down its sending rate, but will ramp back up again until congestion re-occurs. In other words, TCP tries to fill the data pipe with traffic so the data transfer takes as little time as possible. Furthermore, TCP sends blocks of data at a time called a "window of data." Therefore, packets of a given size tend to be transferred in trains making sequential packets of the same size likely rather than a random probability as ARINC assumed in its Monte Carlo analysis.[18] In addition, other applications use non-random patterns that lead to synchronization of data transfers. For example, Voice-over-IP or video conferencing do not use the TCP protocol, but rather employ a User Datagram Protocol ("UDP"), which sends a steady uniform stream of traffic. Network management applications also perform traffic exchanges to collect performance and fault data on steady periodic intervals.

Moreover, ARINC's off-axis e.i.r.p. management algorithm does not provide positive control of an off-axis e.i.r.p. mask exceedance event. It reacts to an exceedance caused by a log-in burst entry or an excessive number of simultaneous bursts by lowering the AES duty cycle. This throws the system into congestion and, in turn, causes routing

[18] File transfers or graphic web page viewing involve large amounts of data so successive large packet sizes would be expected. Such large file transfers will be a reality for passengers using ARINC's service. Connexion by Boeing has experienced a user transferring as much as 535 megabytes of data during a single session.

queues to form, increasing the likelihood that even more packets will be sequential from the platforms and more overlapping bursts will occur. In this regard, ARINC's system allows up to 214 AESs to operate simultaneously, although the maximum number of overlapping bursts to stay below the FCC mask is only 38. This means that under worst-case conditions the aggregate off-axis e.i.r.p. of the SKYLink system can exceed the mask by up to 7.5 dB.[19]

If traffic patterns are used to control the probability of simultaneous transmissions and, thereby the probability of exceeding the mask, then arriving traffic needs to be buffered and randomly time released into the return link. This would require a control variable commanded from the ground for the random time interval for packet release into the link, which would be a function of the number of AESs logged-in. Transmit duty cycle (the percent time the transmitter may be on while transmitting bursts) is claimed by ARINC to be a control parameter but this says nothing about individual random packet release. ARINC's compliance with the FCC's off-axis e.i.r.p. limits is dependent on randomized traffic flow and, therefore, traffic reshaping needs to be a part of any such design.[20]

As Boeing has repeatedly stated, there are many problems with ARINC's simulations, but a fundamental problem with the entire approach is that it is only a prediction of the future. User traffic will evolve rapidly over time so a control regime that depends on a prediction of traffic will fail when the actions of the users do not conform to a previously held model. Thus, any consideration of expected user traffic must address the likelihood that the users will not behave as expected (*i.e.*, when control is exerted). Accordingly, control mechanisms are essential for a properly designed AMSS system. When, how, and how fast must an operator react to unexpected user traffic patterns? Does the operator have to react if the user statistics are out of specification for one second, one minute, one hour, one day, one week, one month or one year? Or, can the operator simply wait until someone complains (*i.e.*, harmful interference is caused)? What matters most from an interference standpoint is how the user traffic is controlled (*i.e.*, how traffic expectations are enforced). This, in turn, is fundamental to ensuring that licensed earth station networks operate within their authorized parameters and maximum interference envelope. This is particularly important in the context of AMSS operations in the 14.0-14.5 GHz band, which are secondary to primary FSS operations in the United States.

The FCC typically licenses the operation of transmitting earth station networks based on standard, verifiable design parameters such as power levels, bandwidths,

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[19] SKYLink Application, File No. SES-LIC-20030910-01261 and SES-AMD-20031223-01860, Technical Supplement at 45-46.

[20] ARINC's original application suggests that "[r]eturn link data is divided into packets that are transmitted randomly." *See id.*, Technical Supplement at 10 (definition of P_{Sim}). It is unclear, however, whether ARINC assumes mere retransmission of random input (which, as discussed above, is an invalid assumption) or ARINC is actively randomizing packet transmission. If the latter approach is correct, ARINC should describe this operational function.

antenna gain and control mechanisms.[21] In addition, the FCC typically defines the maximum interference potential of a transmitting earth station by strictly limiting certain operational parameters in the license (*e.g.*, minimum elevation angle, maximum e.i.r.p. per carrier, maximum e.i.r.p. density per carrier, maximum e.i.r.p. towards the horizon, etc.). By contrast, ARINC relies on inaccurate forecasts of expected user traffic and false assumptions that limit the maximum level of interference its AES network will produce (at least until its congestion control regime engages in an effort to limit the probability of exceeding the FCC mask). Reliance on such simulations and assumptions is extremely risky because they are not verifiable, not under the control of the licensee, and can be easily manipulated to support desired outcomes.

4. Additional Shortcomings in ARINC's Analysis

The preceding discussion has focused on the most significant differences between ARINC's claims and Boeing's assessment of the SKYLink's system's interference potential. This section addresses other unresolved issues, including ARINC's treatment of pointing error, e.i.r.p. variation, absence of a 1 dB margin, and the contribution of the forward uplink to the aggregate off-axis e.i.r.p., which also contribute to the greater interference potential of the SKYLink system and underscore the continuing uncertainties with respect to ARINC's pending application.

Pointing Error

In its Supplemental Comments, Boeing questioned ARINC's unsupported and overly optimistic AES pointing error assumption of 0.1 degrees and provided an alternative estimate.[22] ARINC erroneously claims that "the Boeing analysis pre-supposes pointing inaccuracies line-up solely in the direction of other satellites whereas real-world pointing errors are just as likely to steer the antenna in a direction that has no affect whatever on adjacent satellites."[23] ARINC goes on to call Boeing's analytic approach "primitive."[24]

ARINC's "critique" of Boeing's analysis is entirely without foundation. Boeing explicitly stated the that it used a pointing error of "0.59 degrees in azimuth and 0.38 degrees in elevation" in its simulation,[25] thereby considering pointing error both along

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[21] In the case of AMSS, such parameters include pointing error, e.i.r.p variation, and antenna pattern variation. Each of these design parameters is verifiable and these tests could be repeated by an impendent party such as a testing lab. Once the FCC licenses these parameters, the maximum level of interference that the system will produce is fixed and will not increase so long as they remain in effect.

[22] *See* Boeing Supplemental Comments, Technical Appendix at 6.

[23] ARINC Response, Exh. 1 at 10.

[24] *Id.*

[25] Boeing Supplemental Comments, Technical Appendix at 6.

and orthogonal to the GSO arc -- just as ARINC claims it does in its own simulation.[26] In any event, if there is any fault to be found in this regard, it is with the ARINC simulation, which apparently splits the pointing error evenly into orthogonal axes. This is not a correct assumption because inertial navigation systems are less accurate in heading than in pitch and roll, which results in a larger azimuth error than elevation error.

ARINC has now abandoned its previously claimed overall AES pointing error of 0.1 degrees and is instead including Boeing's estimates of pointing error in its analysis.[27] Understanding and incorporating the various factors that affect overall pointing errors results in a far more accurate value that the 0.1 degree value that ARINC had previously employed. However, this still leaves the question: what is the actual pointing error of SKYLink AESs? ARINC has yet to perform a thorough pointing error analysis of its own. Such an analysis should be a minimum requirement for any AMSS applicant and ARINC should be required to verify its AES dynamic pointing accuracy as was required of Boeing.

E.I.R.P. Variation

In its simulation, ARINC assumes that transponder G/T variation results in an "independent, uniform amplitude variation over a range of +/- 2 dB."[28] This effectively assumes that all AESs are located within G/T contours that are within 4 dB of the peak G/T value for the transponder. This assumption, however, does not give any consideration to AESs that may be outside this G/T contour, perhaps because they are entering or exiting the footprint. There is no mechanism within the ARINC system that enforces this 4 dB of peak assumption (*i.e.*, limits the AES operation to the assumed area). The result is that AESs outside of the assumed coverage area may be transmitting at considerably higher e.i.r.p. levels.

It is possible that ARINC is attempting to address this concern when it says that "the NMS continuously and dynamically controls each AES so that the aggregate input power of the system at the geostationary arc is maintained below -24.25 dBW/4kHz."[29] ARINC, however, does not explain how this is accomplished. All previous descriptions have relied on monitoring the average number of simultaneous accesses over a period of time as a proxy for the aggregate input power. The methods described have always assumed that all of the simultaneous accesses are at a nominal input power which is used to compute a permissible number of accesses based on the -24.25 dBW/4kHz value. This approach does not appear to be compatible with monitoring a computed aggregate input

[26] ARINC Response, Exh. 1 at 10.

[27] *Id.* at 4, Table 1 (Pointing Errors). Strangely, however, the coordination agreement governing ARINC's AMSS operations is based on a pointing accuracy of $\leq$ 0.1 degrees. *Id.*, Exh. 2 at 2.

[28] *Id.* at 4, Table 1 (Power).

[29] *Id.* at 14.

power (from individual AES positions, data rates, and received Eb/Nos) or an aggregate input power reported based on direct measurements at the AES.[30]

1 dB Margin

ARINC's application states that the off-axis e.i.r.p. of the SKYLink system is limited to the FCC off-axis limit minus 1dB with a probability of 99.999%.[31] A similar statement is included in the SES/PanAmSat coordination letter regarding ARINC's AMSS operations.[32] However, this 1 dB of margin appears to be absent from ARINC's most recent analysis.[33] ARINC should explain the differences between its earlier claims regarding the 1 dB margin and its current analysis, including the relationship between the 1 dB margin, its claimed 99.999% compliance level (*i.e.*, whether that claimed level still includes a 1 dB margin) and the operation of its congestion control scheme (*i.e.*, whether congestion control is triggered when noncompliance with the off-axis e.i.r.p mask, or the mask - 1 dB, reaches 1%). The elimination of this 1 dB margin could have a dramatic impact on ARINC's performance claims as well as the validity of the SES/PanAmSat coordination agreement.

Forward Uplink Off-Axis E.I.R.P.

The ARINC Response states that "[t]he contribution of the fixed Ground Earth Station to off-axis e.i.r.p. is small in comparison to a single AES and does not change over time."[34] Boeing assumes that this statement refers to the forward uplink off-axis e.i.r.p. contribution of SKYLink feeder link earth stations, and strongly disagrees with this assertion.

Figure A shows that both the authorized and nominal off-axis e.i.r.p. of the forward (feeder link) uplink are 5 to 10 dB greater than the off-axis e.i.r.p. of a single AES at an e.i.r.p. density of -6.53 dBW/4kHz. Also shown in Figure A is a data point corresponding to 30 dB below the VSAT criteria at 2 degrees of orbital separation. The fact that off-axis e.i.r.p. of the forward uplink is constant only magnifies the problem since the contribution of a single AES is discounted by its relatively low duty cycle. While the forward uplink may contribute three to ten times more off-axis e.i.r.p. than a

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[30] The usefulness of a true aggregate input power for system control is also questionable in ARINC's contention protocol access scheme since the aggregate input power may change from millisecond to millisecond as different AESs transmit bursts, even if the total number of simultaneous accesses remains constant. By the time control could be applied, the highest input power users might be quiescent again. If ARINC has a mechanism that computes and controls aggregate input power rather than simultaneous accesses, ARINC should describe it in detail.

[31] ARINC Application, Technical Description at 43.

[32] ARINC Response, Exh. 2 at 2.

[33] *See, e.g.*, ARINC Response, Exh. 1 at 7-8.

[34] *Id.*, Exh. 1 at 4, Table 1 (Power).

single AES while it is transmitting, the forward uplink will contribute as much to the off-axis e.i.r.p. as 10 to 50 AESs that are logged in but only transmitting intermittently.

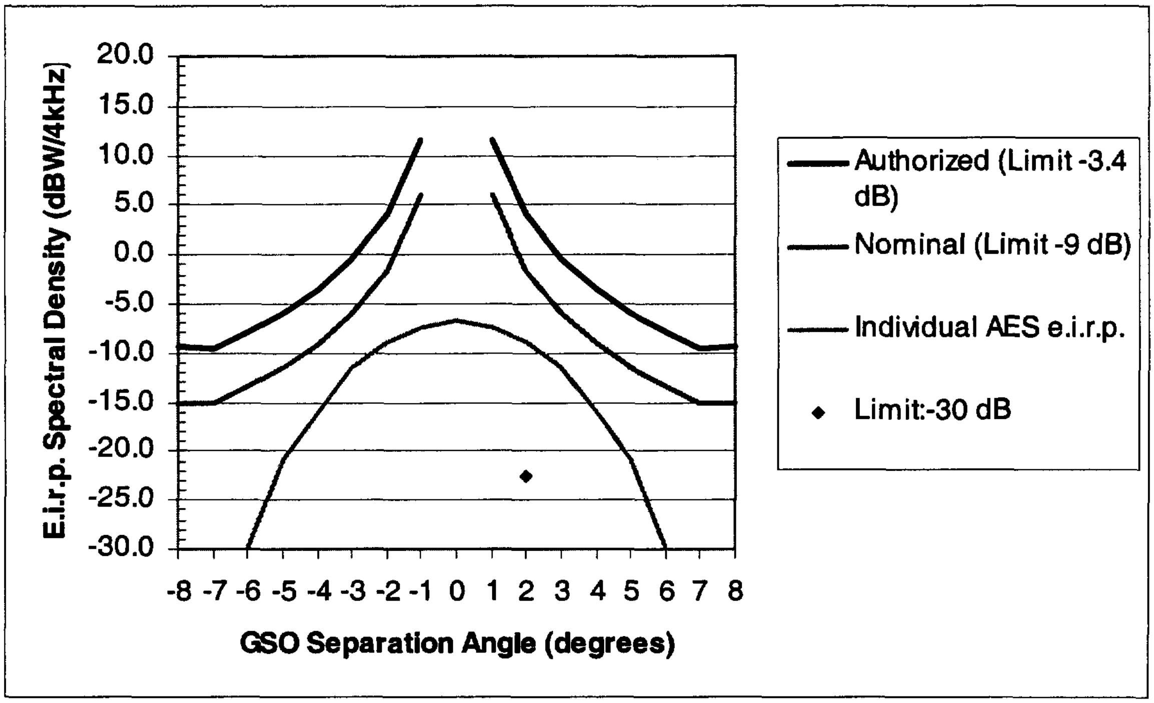

Figure A. Forward Uplink Off-Axis E.I.R.P. at Authorized and Nominal E.I.R.P. versus Individual AES Off-Axis E.I.R.P.

Figure B shows the aggregate AES off-axis e.i.r.p. as well as the total off-axis e.i.r.p. resulting from the sum of the uplink and AES signals. As shown, the total effect is several dB greater than just the aggregate of the AES signals. This would occur at a range of orbital locations.

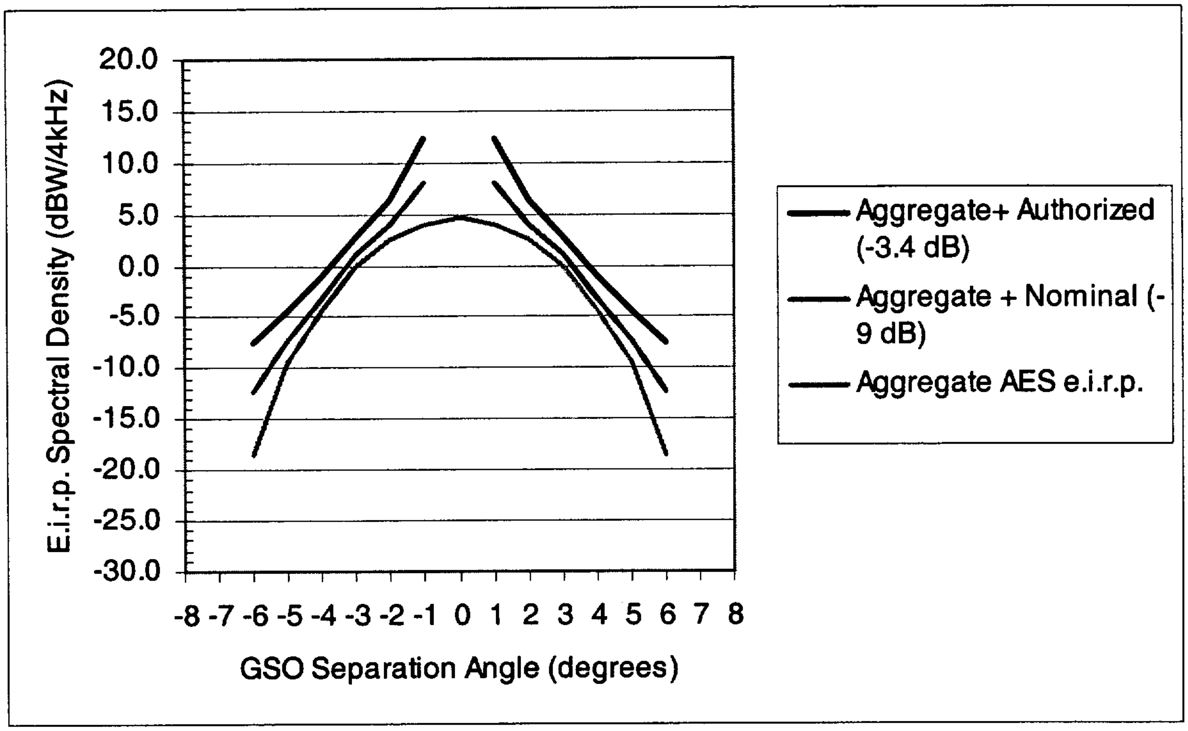

Figure B. Aggregate AES Off-Axis E.I.R.P. and Total effect of AES and Uplink Off-Axis E.I.R.P.

As previously noted by Boeing, ARINC's forward uplink will increase the aggregate off-axis e.i.r.p. of the ARINC system by 45% if operated at the authorized input power level, 3.4 dB below the -14 dBW/4 kHz limit with a Rule 25.209 compliant antenna when the AES uplinks are at the off-axis e.i.r.p. limits.[35] ARINC now claims that it will actually operate this link at 9 dB below the -14 dBW/4 kHz limit.[36] However, Boeing has already noted that this would still significantly increase the aggregate off-axis e.i.r.p. by 12.5%.[37] In any event, the FCC must consider the forward uplink's maximum authorized uplink power level in assessing the overall interference potential of the SKYLink system. To the extent that ARINC requests the FCC to consider a reduced maximum authorized forward uplink power level (-23.01 dBW/4 kHz), it should formally modify its forward uplink earth station power to reflect this reduced level.

Given ARINC's erroneous representation that "[t]he contribution of the fixed Ground Earth Station to off-axis e.i.r.p. is small in comparison to a single AES," it is not clear that ARINC has properly included the contribution of its forward uplink in its Monte Carlo simulation. Fully accounting for the forward uplink off-axis e.i.r.p. will have a non-linear affect on the probability that the SKYLink system will exceed the FCC mask, which would effectively shift the mean off-axis e.i.r.p. upwards. However, out at

[35] *See* Boeing Comments at 11; Boeing Further Comments at 19; Boeing Supplemental Comments at 7.

[36] ARINC Response, Exh. 1 at 14.

[37] Boeing Further Comments at 19.

the tails of the off-axis e.i.r.p. distribution, where they exceed the off-axis limits, a small change in the mean level can cause a disproportional increase in the probability of exceeding the FCC mask. Unless ARINC properly includes the off-axis e.i.r.p. of the forward uplink in its Monte Carlo simulation, this effect will remain unquantified.

ARINC now dismisses the off-axis e.i.r.p. contribution of the forward uplink by claiming, without support, that it is 30 dB below the FCC off-axis e.i.r.p. mask.[38] Even assuming that the forward uplink operates at 9 dB below the -14 dBW/4kHz limit (5.6 dB below the authorized level), ARINC's uplink antenna would have to be 21 dB better than the Rule 25.209 limit to make its claim accurate. This could only be possible with a -17 dBi or 71 dB of discrimination at a 2 degree separation angle along the geostationary arc. Such a claim is somewhere between very improbable and physically impossible, and plainly cannot be accepted without supporting data. Even if possible, such as due to a deep null at 2 degrees, the SKYLink system would still impact satellites at other separations and so would need to be taken into account in the overall calculation of the probability of interference. To do otherwise is to misrepresent the system to the adjacent satellites with which they are coordinating.

Boeing does not object to the use of a co-frequency forward uplink and believes that such an approach is an efficient use of spectrum. However, in order to employ such uplinks, ARINC must fully account for the off-axis e.i.r.p. contribution of the forward uplink in the SKYLink system's aggregate off-axis e.i.r.p., including in its Monte Carlo simulation at the authorized level (or at a lower level if ARINC formally modifies its earth station authorization) for its simulation to have any validity. Additionally, if ARINC claims a better off-axis gain pattern for the forward uplink antenna than the Rule 25.209 mask, then it should support the claim with hard data.

5. Misleading Comparison of Relative Probability of Meeting the Off-Axis E.I.R.P. Mask

ARINC claims that the SKYLink system will not exceed the FCC's off-axis e.i.r.p. mask for routinely authorized VSATs more than 0.001% of the time. Of course, there are numerous uncertainties regarding this claimed value as described above and in Boeing's previous filings. In addition, ARINC misses the mark when it suggests that the SKYLink system is "at least ten times better [at meeting the FCC mask] than Boeing's Connexion system,"[39] because ARINC's claimed compliance level is 99.999% and the Connexion by Boeing[SM] system is designed to achieve 99.99% compliance under worst-case conditions. As discussed below, given the significant differences between the ARINC and Boeing approaches to interference assessment and control, this is an apples-to-oranges comparison.

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[38] ARINC Response, Exh. 1 at 15.

[39] *Id.* at 2.

ARINC's value apparently is an overall performance level based on expected traffic, and is based on the notions that any real system is not fully loaded all of the time and that even in the busiest hour the percentage of the time spent at peak capacity is relatively small. ARINC also has assumed an expected traffic distribution such that the contributions of pointing error and e.i.r.p. variation are completely swamped. As Boeing has demonstrated in this proceeding, numerous other assumptions made by ARINC in its interference calculations are either plainly erroneous or entirely without foundation and cannot be accepted. Thus, not only is ARINC's claimed compliance level of 99.999% highly questionable, but this overall value cannot be compared to the stated compliance level of the Connexion by Boeing system.

On the other hand, it is correct to compare on an apples-to-apples basis the SKYLink system's 1% probability of exceeding the FCC mask under worst-case conditions (based on the control mechanisms ARINC has described) with the Connexion by Boeing system's 0.01% probability of exceeding the mask under worst-case conditions.[40] Boeing is fully aware that its analysis of the SKYLink system considers peak demand conditions. This is precisely the approach taken by the FCC in licensing the Connexion by Boeing system (defining the maximum interference potential of Boeing's AMSS operations), and considered by the international community in the context of ITU-R studies supporting the Ku-band AMSS allocation and Recommendation ITU-R M.1643. Examining AMSS interference potential under worst-case conditions is consistent with FCC licensing precedent, and is entirely reasonable in the context of reviewing ARINC's application given the difficulty in predicting expected user traffic and the lack of mechanisms to enforce expected traffic in the SKYLink system.

[40] Comparing overall compliance levels also reveals that the Connexion system controls off-axis interference to a significantly higher standard than the SKYLink system. It is reasonable to expect that if control is exerted at the 0.01% value during worst-case conditions in the Connexion system, then considering actual traffic the overall probability of exceeding the FCC mask loading is orders of magnitude lower. This means that the 0.01% value quoted by Boeing, without considering expected traffic, is far more stringent than the 0.001% value quoted by ARINC based on expected traffic.