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

In the matter of	)	
	)	
ARINC Incorporated	)	File Nos. SES-LIC-20030910-01261
	)	SES-AMD-20031223-01860
Application for Blanket Authority for Operation of Up to One Thousand Technically Identical Ku-Band Transmit/Receive Airborne Mobile Stations Aboard Aircraft Operating in the United States and Adjacent Waters	)	

ORDER AND AUTHORIZATION

Adopted: April 5, 2005 **Released:** April 6, 2005

By the Chief, International Bureau and the Chief, Office of Engineering and Technology

I. INTRODUCTION

1. With this order, we grant ARINC Incorporated authority for operation of up to one thousand technically-identical transmit/receive aircraft Earth stations in the 14.0-14.5 GHz (Earth-to-space) and 11.7-12.2 GHz (space-to-Earth) frequency bands. These Earth stations will be used for Aeronautical Mobile Satellite Service ("AMSS"), to be provided via leased transponders on an existing Fixed Satellite Service ("FSS") satellite, subject to conditions specified herein. This authorization will permit ARINC Incorporated to provide broadband data communications service for passengers and crew of commercial airliners, corporate business jets, and smaller aircraft in the continental United States and over U.S. territorial waters. Implementation of this authorization will enhance competition in an important sector of the mobile telecommunications market in the United States.

II. BACKGROUND

A. Preceding Developments Relevant to Authorization of AMSS Operation with Ku-Band FSS Satellites

2. In license orders issued in 2001, the International Bureau ("Bureau") and the Office of Engineering and Technology ("OET") granted applications by The Boeing Company for authority to provide AMSS via leased transponders on existing FSS satellites, using the same frequency bands that ARINC's application specifies.[1] At that time, there was no domestic allocation for AMSS in either the

[1] Boeing Company Application for Blanket Authority to Operate Up to Eight Hundred Technically Identical

11.7-12.2 GHz band or the 14.0-14.5 GHz band, which are domestically and internationally allocated on a primary basis for FSS operation and heavily used in the United States for very small aperture terminal ("VSAT") FSS operation. In an initial order granting authority for receive-only operation, the Bureau and OET held that a waiver was justified to allow Boeing to use the 11.7-12.2 GHz band for AMSS downlink transmission, primarily because Boeing proposed to use leased transponders on previously-licensed satellites within the terms of existing coordination agreements.[2] In considering Boeing's later request for authority for AMSS uplink transmission in the 14.0-14.5 GHz band, the Bureau and OET noted that ITU-R Working Party 4A had endorsed a pertinent U.S.-sponsored Draft New Recommendation ("DNR").[3] The DNR concluded that AMSS systems using transponders on FSS satellites could compatibly operate in the 14.0-14.5 GHz uplink band on a secondary basis if they maintain aggregate earth station off-axis e.i.r.p. density within levels permitted under coordination agreements between the operators of the satellites housing the leased transponders and operators of nearby FSS satellites.[4] Noting that all of the potentially-affected parties that commented on Boeing's application concurred with the DNR, the Bureau and OET granted Boeing a waiver for non-interfering, non-protected AMSS uplink operation in the 14.0-14.5 GHz band, subject to conditions based on the DNR guidelines.[5]

3. In 2001, OET also granted authority to ARINC for experimental test operation of another 12/14 GHz AMSS system, to be known as SKYLink℠.[6] OET later modified the experimental license to permit commercial operation of fifteen SKYLink terminals until May 1, 2006, for purposes of market study.[7]

4. The 2003 World Radiocommunications Conference (WRC-03) added a worldwide secondary Earth-to-space AMSS allocation in the 14.0-14.5 GHz band. At the same time, the ITU Radiocommunication Sector adopted ITU-R M.1643, which sets forth detailed recommendations pertaining to operation of AMSS aircraft terminals in the 14 GHz band.[8] Annex 1, Part A, of M.1643 specifies recommended requirements for protection of FSS networks that are essentially identical to the conditions in Boeing's 14 GHz AMSS authorization.

Transmit and Receive Mobile Earth Stations Aboard Aircraft in the 14.0-14.5 GHz and 11.7-12.2 GHz Frequency Bands, *Order and Authorization*, 16 FCC Rcd 5864 (Int'l Bur. and OET, 2001) ("*Boeing 12 GHz License Order*") and *Order and Authorization*, 16 FCC Rcd 22645 (Int'l Bur. and OET, 2001) ("*Boeing 14 GHz License Order*").

[2] *Boeing 12 GHz License Order* at ¶¶ 9-10.

[3] Document 4A/278-E (26 September 2001).

[4] *Boeing 14 GHz License Order* at ¶13. The Bureau and OET also took note of favorable recommendations in other ITU-R working-party documents concerning compatibility with radionavigation, space research, Land Mobile Satellite Service, radio astronomy, and terrestrial fixed services in the 14 GHz band.

[5] *Id.* at ¶16. Boeing commenced providing broadband in-flight Internet, data, and entertainment service on international flights in 2004. *See* Boeing Press Release, http://www.boeing.com/news/releases/2004/q2/nr_040511j.html (May 11, 2004).

[6] *See* File No. 0054-EX-PL-2001, modified by File No. 0029-EX-ML-2003 and File No. 0029-EX-ML-2004 (Call Sign WC2XPE).

[7] File No. 0130-EX-RR-2004.

[8] Rec. ITU-R M.1643, Technical and operational requirements for aircraft Earth stations of aeronautical mobile-satellite service including those using fixed-satellite service network transponders in the band 14-14.5 GHz (Earth-to-space) (2003).

5. The Commission subsequently amended the domestic Table of Frequency Allocations to add a secondary Earth-to-space AMSS allocation in the 14.0-14.5 GHz band.[9] Further, in a Notice of Proposed Rulemaking released this year ("*Ku-Band AMSS NPRM*"), the Commission proposed to amend the Table of Allocations to recognize AMSS operations in the 11.7-12.2 GHz band and to establish rules prescribing licensing procedures and operational requirements for Ku-Band AMSS operations.[10] At present, however, there are no Commission service rules that explicitly pertain to licensing or operation of AMSS in the 14.0-14.5 GHz band, and there is no domestic allocation for AMSS in the 11.7-12.2 GHz band.

B. Procedural History

6. ARINC filed the instant application for authority for full-scale commercial operation of the SKYLink System in September, 2003. The application was placed on public notice on October 15, 2003. In December 2003, ARINC filed an amendment to correct minor errors in its technical description. It filed supplemental information concerning coordination and aggregate earth station off-axis e.i.r.p. in June and September of 2004.[11] Boeing and PanAmSat Corporation filed comments on the application. PanAmSat contended that the application needed clarification in one respect but otherwise raised no objection. Boeing maintained in initial comments, and in later written presentations, that the design of the SKYLink System does not comport with recommendations in ITU-R M.1643 and that ARINC had not shown that its system would sufficiently limit aggregate earth station off-axis e.i.r.p. density. Boeing contended that the SKYLink application should not be granted unless ARINC amends it to cure the alleged deficiencies.

C. System Description

7. The SKYLink System is designed to provide two-way, wideband data communications links between multiple aircraft Earth stations and terrestrial networks. More specifically, the SKYLink System will afford in-flight access to the Internet and private corporate networks, enabling air travelers to locate and transfer data files, business records and presentations to and from laptop computers. Flight crews may also use SKYLink for company access to facilitate flight and layover planning.

8. Each SKYLink aircraft Earth station ("AES") terminal will operate with a steerable 11.5-inch parabolic dish antenna mounted in a radome on the aircraft tail stabilizer. The AES antenna, which can simultaneously receive in the 11.7-12.2 GHz band while transmitting in the 14.0-14.5 GHz band, will be continuously steered in three axes under the control of an open-loop algorithm to optimize coupling with the target satellite, using stored ephemeris data and inputs from the aircraft's inertial navigation system. A maneuver or navigational failure that prevents an AES antenna from locking on the satellite transponder will, by disrupting the received signal, cause the transmitter to shut down within 250

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[9] Amendment of Parts 2, 25, and 87 of the Commission's Rules to Implement Decisions from the World Radiocommunications Conferences Concerning Frequency Bands Between 28 MHz and 36 GHz and to Otherwise Update the Rules in this Frequency Range, ET Docket No. 02-305, *Report and Order*, 18 FCC Rcd 23426 at ¶76 (2003). The amendment deleted a proviso that had limited the scope of the Mobile Satellite Services allocation in the band in question by specifically excluding AMSS.

[10] Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service, *Notice of Proposed Rulemaking*, IB Docket No. 05-20, FCC 05-14 (rel. Feb. 9, 2005).

[11] SES-AMD-20031223-0186, filed Dec. 23, 2003; letters with attachments from Carl R. Frank, counsel for ARINC, to the FCC Secretary dated June 3 and Sept. 30, 2004.

milliseconds.

9. The Skylink System will operate with one or more leased transponders on SES Americom's AMC-1 satellite at 103° W.L. and a hub earth station in California. The hub station uses the same channel in the 14.0-14.5 GHz band for "forward-link"[12] transmission via a given satellite transponder that SKYLink AES terminals use for "return-link" transmission via that transponder. Similarly, a transponder transmits in the same channel in the 11.7-12.2 GHz band for the "forward" downlink to SKYLink AES terminals and the "return" downlink to the hub earth station. To enable this mode of operation, the SKYLink System employs a Paired Carrier Multiple Access technique that allows simultaneous transmission of independent signals in the same bandwidth.

10. Data entering and leaving the SKYLink system is formatted with the TCP/IP protocol (Transmission Control Protocol/Internet Protocol). TCP/IP data packets are formatted within the system for transmission with additional overhead for error correction encoding and interleaving to provide a robust bi-directional channel.

11. SKYLink forward links can support data-transmission rates up to 3.5 Mbps. Forward-link signals are encoded using a randomized rate 1/3 code, direct sequence spread spectrum, with an integer chip rate to fit within the available bandwidth, then applied to a pulse shaping Offset-Quadrature Phase Shift Keying modulator that formats the signal for transmission over a 36 MHz transponder. The return-link waveform is direct-sequence-spread, Gaussian Minimum Shift Keyed with Forward Error Correction encoding and interleaving. Individual AES terminals access the shared return link using a random-access-burst Code Reuse Multiple Access Aloha contention protocol.[13] Multiple terminals can concurrently share a single SKYLink return-link frequency channel using burst transmissions with the same or different CDMA spreading codes.

12. A Network Management System (NMS) co-located with the hub earth station controls access to the SKYLink System and employs both open-loop and closed-loop power control to manage operation of logged-in AES terminals. The open-loop power control provides an estimate of the required uplink transmit power, based on a combination of the received signal strength at the AES receiver and an adjustment parameter provided in parameter-change messages from the NMS. The closed-loop algorithm accounts for signal losses and noise floor increases in both the return uplink to the satellite and the return downlink to the hub earth station and determines the content of the adjustment messages.

13. The SKYLink System uses on-board and ground-based fault-management controls to minimize interference from malfunctioning AES terminals. The terminals are programmed to cease transmission upon self-detection of hardware failure or out-of-tolerance operation or in the event of failure to receive a periodic status message. The NMS will order an AES to shut down if it fails to respond properly to a power-control or data-rate command.

III. DISCUSSION

A. Points of Communication

[12] ARINC uses the term "forward link" to refer to transmission from the hub earth station to an aircraft Earth station ("AES") via the SES satellite and "return link" to refer to transmission in the opposite direction.

[13] SKYLink Application, Exhibit 3 at 17.

14. PanAmSat notes that although the SKYLink application indicates that SES Americom's AMC-1 satellite at 103º W.L. is the only proposed orbital point of communication, a draft license filed with the application indicates that the SKYLink System will operate with the AMSC-1 satellite at 101° W.L. PanAmSat also maintains that the application could be construed as requesting a blanket waiver that would allow operation with any satellite, at any orbital location, without coordinating with operators of adjacent satellites. ARINC describes the reference to AMSC-1 as a typographical error,[14] which has been corrected by a subsequent amendment. As amended, ARINC's application clearly does not request authority for operation with any satellite other than AMC-1, and we do not grant authority for operation with any other satellite in this authorization.

B. Compliance with M.1643 Guidelines Concerning Control of Terminal Operation

15. Boeing maintains that the design of the SKYLink System does not comport with a key provision of Recommendation ITU-R M.1643.[15] The provision in question is in Paragraph 4 of Annex 1, Part A, of ITU-R M.1643. The provision states that aircraft Earth stations transmitting in the 14.0-14.5 GHz band "should be subject to … monitoring and control by an NCMC [*i.e.*, a network control and monitoring center] or equivalent facility" and "must be able to receive at least 'enable transmission' and 'disable transmission' commands from the NCMC." According to Boeing, this means that 14 GHz AES terminals should operate on a transmit-on-command basis; *i.e.*, each terminal transmission should commence only upon receipt of a separate command instruction from the network operation center that specifically instructs the terminal to transmit at that moment. Boeing contends that, as described in ARINC's license application, the SKYLink System will not operate in this manner, as the application indicates that the system will operate with an access protocol that will allow AES terminals to transmit data bursts without receiving separate command signals for each transmission.[16] Boeing stresses that its own system operates with a transmit-on-command protocol and that the order that granted its AMSS authorization imposed conditions that are identical, in substance, to the network-control guidelines in ITU-R M.1643, Annex 1, Part A.[17]

16. We do not agree that transmit-(only)-on-command operation, as defined by Boeing, is necessary for consistency with Recommendation ITU-R M.1643. The provision in M.1643, Annex 1, Paragraph 4 that Boeing cites merely states that operation of 14 GHz AES terminals should be monitored and controlled by a network control center and must be able to receive enable-transmission and disable-transmission commands. It does not say that the terminals should transmit only on command, nor is this clearly implied. Rather, the following sentences in Annex 1, Paragraph 4 merely say that AES terminals should cease transmission while receiving parameter-change commands and that the network control center should be able to monitor terminal operation to detect malfunctioning.[18]

[14] Response of ARINC Incorporated filed Nov. 28, 2003 ("ARINC Response"), at 10.

[15] Comments of The Boeing Company filed Nov. 14, 2003 ("Boeing Comments"), at 5-7; Further Comments of The Boeing Company filed Dec. 18, 2003 ("Boeing Further Comments"), at 7-12; Supplemental Comments of The Boeing Company filed May 21, 2004 ("Boeing Supplemental Comments"), at 8-12.

[16] Boeing Comments at 7; Boeing Supplemental Comments at 10.

[17] *See Boeing 14 GHz License Order* at ¶¶ 18 and 19(h)(3) and (4).

[18] The complete text of the following sentences is as follows:

> AES must automatically cease transmission immediately on receiving any 'parameter change' command, which may cause harmful interference during the change, until it receives an 'enable

17. As described by ARINC, the SKYLink System includes a Network Management System ("NMS") that continuously monitors operation of AES terminals and dynamically controls their input power, data transmission rates, and duty cycles and the number of terminals that can be logged-in. The application also indicates that the SKYLink NMS can detect terminal malfunctions and that malfunctioning terminals will be shut down on command from the NMS or by on-board fault-management algorithms. We therefore find that ARINC's operational description of the SKYLink System is consistent with the network-control guidelines in M.1643.

C. Uplink Interference

1. Coordination

18. ARINC has filed a copy of an uplink coordination agreement with SES Americom and PanAmSat Corporation.[19] In addition to operating AMC-1, SES Americom operates geosynchronous FSS satellites in the adjacent orbital locations of 101º W.L. and 105º W.L. PanAmSat operates a geostationary FSS satellite at 99º W.L. The coordination agreement states, *inter alia*, that ARINC will control the number of logged-in terminals and data-transmission rates to limit the probability to 0.001 percent or less that the SKYLink System will generate aggregate off-axis e.i.r.p. spectral density toward the geostationary arc exceeding a one-dB margin below the maximum permissible levels for a routinely-licensed digital VSAT transmitter.[20] The agreement also states that ARINC will control AES transmitter power in 0.25 dB steps; limit AES antenna pointing error to 0.1° or less with inertial navigation data refreshed every 20 ms; terminate transmission from an AES terminal within 250 ms of return-link loss; implement a fault-management system that will terminate AES transmission when out of tolerance conditions are detected; and maintain continuous monitoring and oversight of AES operation from a ground network operations center. Further, the agreement states that ARINC will accept interference from adjacent satellites that would not harmfully interfere with Earth stations with antennas conforming to the reference patterns specified in Section 25.209 of the Commission's rules, and that ARINC will terminate SKYLink transmissions immediately upon notification from affected parties of resultant harmful interference. The coordination agreement includes stipulations by SES Americom and PanAmSat to the effect that they have no objection to authorization of SKYLink operation in accordance with the terms of the agreement and the specifications in the SKYLink license application.

19. ARINC asserts that it has coordinated with "all adjacent FSS licensees" and contends that this resolves any "genuine" technical issue.[21] Although the execution of the agreement with SES Americom and PanAmSat weighs significantly in ARINC's favor, there is no established Commission policy for authorization of AMSS operation in the 14.0-14.5 GHz band based only on coordination. The Commission invited comment on a petitioner's recommendation for adoption of such a policy in the Ku-Band AMSS rulemaking,[22] but at this point the issue is unresolved. Under the Commission's recently-

> transmission' command from the NCMC. In addition, it should be possible for the NCMC to monitor the operation of an AES to determine if it is malfunctioning.

Recommendation ITU-R M.1643, Annex 1, Part A, ¶4.

[19] *See* letter with attachments from Carl R. Frank to the FCC Secretary dated Sept. 30, 2004.

[20] *See* ¶20, *infra*.

[21] Reply to Supplemental Comments of the Boeing Company filed June 3, 2004 ("ARINC Reply to Supplemental Comments"), at 8.

[22] *Ku-Band AMSS NPRM* at ¶40.

adopted rules for non-routine earth-station licensing, applicants for authority to operate 14 GHz FSS earth stations with antennas as small as those used with SKYLink AES terminals must show that the proposed operation has been coordinated with operators of satellites within six degrees of the target satellite if the applicant relies on coordination in lieu of compliance with technical performance standards.[23] We note, however, that ARINC has provided no evidence of coordination with Telesat Canada, which operates a co-frequency FSS satellite only slightly more than four degrees of orbital longitude from AMC-1.[24] We also note that the coordination agreement with SES Americom and PanAmSat is predicated on representations pertaining to the SKYLink System's performance and that Boeing disputes these representations. We therefore conclude that ARINC's agreement with PanAmSat and SES Americom does not obviate the need to consider Boeing's technical arguments, which are addressed in the paragraphs below.

2. Probability of Exceeding Aggregate Off-Axis e.i.r.p. Density Levels

20. Recommendation ITU-R M.1643 states that AMSS systems should keep off-axis e.i.r.p. density in the 14.0-14.5 GHz uplink band within "the levels that have been published and coordinated for the specific and/or typical Earth station(s) pertaining to FSS networks."[25] In the United States, the 14.0-14.5 GHz band is primarily used for uplink transmission by Very Small Aperture Terminal ("VSAT") FSS Earth stations – *i.e.*, FSS Earth stations with antennas less than 5 meters in diameter. VSAT Earth stations, like other FSS Earth stations, are subject to limits on off-axis antenna gain toward the geostationary-satellite-orbit arc specified in Section 25.209 of the Commission's rules. In addition, digital 12/14 GHz VSAT Earth stations that have been "routinely" authorized – *i.e.*, authorized without meeting the coordination and engineering-analysis requirements set forth in Section 25.134(b) – are subject to a limit of -14 dBW/4kHz on input power density specified in Section 25.134(a)(1). In combination, the relevant off-axis gain limits in Section 25.209 and the input-power limit in Section 25.134(a)(1) effectively define the following maximum levels of off-axis uplink e.i.r.p. density toward the geostationary-satellite-orbit arc from a single routinely-licensed digital VSAT station transmitting in the 14.0-14.5 GHz band:[26]

Angle off-axis	Maximum e.i.r.p. in any 4 kHz band
$1.25^\circ \leq \theta \leq 7.0^\circ$	$15 - 25\log_{10}\theta$ dBW
$7.0^\circ < \theta \leq 9.2^\circ$	-6 dBW
$9.2^\circ < \theta \leq 48^\circ$	$18 - 25\log_{10}\theta$ dBW
$\theta > 48^\circ$	-24 dBW.

21. In a decision issued several years ago, the Bureau held that Section 25.134(a) implicitly prohibited routinely-authorized digital VSAT networks from generating aggregate off-axis e.i.r.p. density above the levels specified in the preceding paragraph (which we will refer to hereafter as "the VSAT

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[23] 2000 Biennial Regulatory Review – Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage By, Satellite Network Earth Stations and Space Stations, *Fifth Report and Order in IB Docket No. 00-248 and Third Report and Order in CC Docket No. 86-496*, FCC 05-63 (rel. March 15, 2005) ("*Fifth Report and Order in Docket 00-248*"), Appendix B, ¶¶ 21-22 (amending 47 C.F.R. § 25.212 and adding 47 C.F.R. § 25.220).

[24] *See* ARINC Response at 11.

[25] Rec. ITU-R M.1643, Appendix 1, Part A, ¶1.

[26] Theta is the angle in degrees from the axis of the main lobe.

emission envelope").[27] The Bureau determined that when two or more remote stations in a digital VSAT network with a random-access "contention" protocol transmit simultaneously in the same frequency channel with the maximum input power specified in Section 25.134(a), their aggregate off-axis e.i.r.p. will occasionally exceed the VSAT emission envelope by 3 dB or more for brief periods of time.[28] The Bureau granted a blanket waiver, however, to allow existing VSAT systems using such access protocols to continue operating with them pending resolution of relevant interference issues in a rulemaking proceeding.[29]

22. The Commission concluded more recently that Section 25.134 should be amended to allow use of contention protocols permitting statistically-infrequent simultaneous co-frequency transmissions that briefly elevate aggregate earth-station off-axis e.i.r.p. density above the VSAT emission envelope.[30] Specifically, the Commission proposed to amend Section 25.134 to allow VSAT systems using contention protocols to generate aggregate off-axis e.i.r.p. continuously exceeding the VSAT emission envelope for 100 milliseconds or less by amounts varying inversely with the overall percentage of the time that the envelope is exceeded: 2 dB over the envelope one percent of the time, 4 dB over 0.1% of the time, 6 dB over 0.01% of the time, 8 dB over 0.001% of the time, etc.[31] The proposed rule would also apply to VSAT networks using contention access protocols in combination with CDMA.[32]

23. In the recent *Ku-Band AMSS NPRM* the Commission invited comment on a proposed requirement that Ku-band AMSS systems allowing simultaneous co-frequency transmissions by multiple AES terminals must limit the off-axis e.i.r.p. density generated by a simultaneously-transmitting terminal to levels calculated by reducing the limits in the VSAT emission envelope by 10*log(N), where N represents the number of terminals transmitting simultaneously in the same frequency range.[33]

24. The SKYLink System operates with an Aloha/CDMA access protocol that allows multiple simultaneous co-frequency AES transmissions, relying on code differentiation to minimize self-interference. Because SKYLink AES antennas are not large enough to suppress side-lobe gain to the extent necessary for conformance with the limits in Section 25.209(a)(1), ARINC proposes to compensate by limiting AES input power density to levels well below the -14 dBW/4kHz limit for routinely-authorized digital VSAT Earth stations. ARINC determined that if the aggregate input-power spectral density of simultaneously-transmitting co-frequency SKYLink AES terminals does not exceed -24.25 dBW/4kHz, the system's aggregate uplink off-axis e.i.r.p. density will not exceed a one-dB margin below

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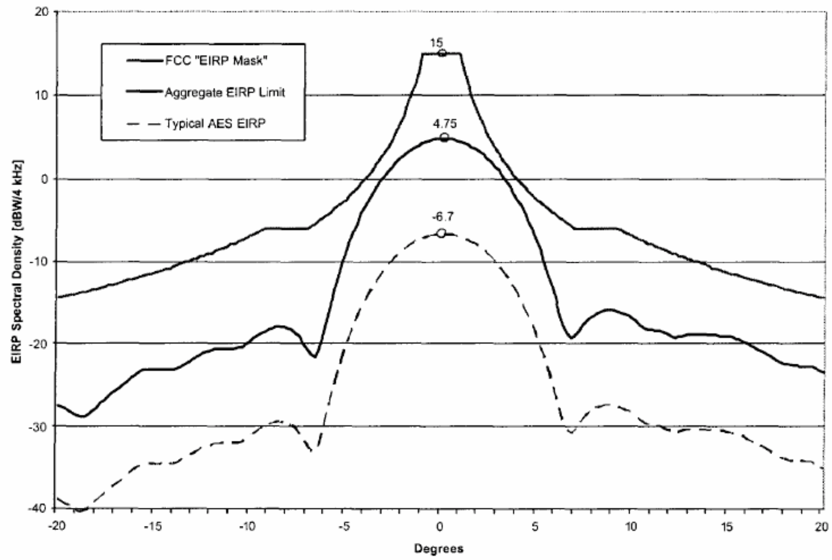
[27] Petition of Spacenet, Inc. for a Declaratory Ruling that Section 25.134 of the Commission's Rules Permits VSAT Remote Stations in the Fixed Satellite Service to Use Network Access Schemes that Allow Statistically Infrequent Overlapping Transmissions of Short Duration, or, in the Alternative, for Rulemaking to Amend that Section, 15 FCC Rcd 23712 (Int'l Bur. 2000) ("*VSAT Blanket Waiver Order*").
[28] *Id.*, Appendix A.
[29] *Id.* at ¶12.
[30] 2000 Biennial Regulatory Review – Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage By, Satellite Network Earth Stations and Space Stations, *Further Notice of Proposed Rulemaking*, IB Docket No. 00-248, 17 FCC Rcd 21432 ¶85 (2002), *Sixth Report and Order and Third Further Notice of Proposed Rulemaking*, FCC 05-62 ¶¶ 103 and 136 (rel. March 15, 2005) ("*Sixth R&O and Third FNPRM"*).
[31] *Sixth R&O and Third FNPRM* at ¶119.
[32] *Id.* at ¶128.
[33] *Ku-Band AMSS NPRM* at ¶¶ 36-37. The Commission recently adopted analogous off-axis e.i.r.p. limits for Earth Stations on Vessels transmitting in the 14.0-14.5 GHz band. *Sixth R&O and Third FNPRM*, Appendix B at ¶5.

the VSAT emission envelope at the worst-case angle, as depicted by the following diagram.[34]



ARINC asserted in its application that the input power density into a single SKYLink AES terminal would never exceed -24.25 dBW/4kHz and that the aggregate input power density into simultaneously-transmitting SKYLink AES terminals would be kept below that level *almost* all the time, through dynamic network control of AES power, log-ins, and data transmission rates.[35] Specifically, ARINC estimated that with 214 SKYLink AES terminals logged in over one transponder the probability of aggregate earth-station on-axis e.i.r.p. density exceeding the –24.25 dBW/4 kHz level at any given point in time would be less than 0.001 percent.[36] ARINC asserted that the SKYLink NMS would authorize no more than 214 terminals to be logged in concurrently and therefore maintained that the system's aggregate off-axis e.i.r.p. would be within the VSAT emission envelope at least 99.999 percent of the time.[37]

25. In response to criticism of its initial showing in this regard, ARINC reported that it had performed two Monte Carlo simulations to verify the probability estimate.[38] ARINC conducted one such simulation to determine the probability that given numbers of simultaneous co-frequency AES transmissions at the maximum data rate (128 bps) would generate aggregate off-axis e.i.r.p. density exceeding the VSAT emission envelope. For purposes of this simulation, ARINC assumed that the AES terminals would be uniformly distributed within the transponder footprint and specified expected values for variation in AES antenna patterns, power-control error, inherent AES pointing error, pointing error due to airframe flexure and inertial-navigation inaccuracy, and variance in radiated power due to

[34] SKYLink Application, Exhibit 3 at 44 (as amended).
[35] *Id.* at 45.
[36] *Id.* The estimate was based on assumptions pertaining to customer usage and geographic distribution of active terminals that were not specified in the application.
[37] *Id.* at 10, 45, and 46. *See also* ARINC Reply to Supplemental Comments, Exhibit 1 at 2.
[38] ARINC Reply to Supplemental Comments at 4. Monte Carlo simulation repeatedly generates random values for uncertain variables to predict a system's behavior.

transponder gain-to-noise variation.[39] ARINC derived the expected values for these variable factors from design parameters, information obtained from manufacturers, and "reasonable and conservative" estimates.[40] ARINC conducted a second Monte Carlo simulation to estimate the probability that a given number of simultaneous transmissions will occur when a given number of SKYLink AES terminals are logged in over a single transponder. The second simulation was based on assumptions as to message-size distribution, the number of users per terminal, the relative proportions of business and recreational use, the ratio of return-link to forward-link transmission, and monthly and daily demand patterns, *inter alia*.[41] Using the probability estimates obtained from the two simulations, ARINC applied a standard formula to calculate the probability that the SKYLink System's aggregate uplink off-axis e.i.r.p. spectral density would exceed the VSAT emission envelope when various given numbers of AES terminals are logged-in over one transponder.[42] ARINC asserted that the results confirmed that its system would keep aggregate off-axis e.i.r.p. density within the envelope 99.999 percent of the time.

26. Boeing disputes ARINC's probability estimate on several grounds. Boeing argues that the estimate is belied by statements in the SKYLink application regarding operation of a congestion-control algorithm that would reduce AES duty cycles in high-traffic situations. Specifically, Boeing points out that, as described, the congestion controller would intervene only if the number of simultaneous AES transmissions reaches a level at which, by ARINC's admission, aggregate off-axis e.i.r.p. density would exceed the VSAT emission envelope one percent of the time. Hence, Boeing maintains that the SKYLink System is designed to limit the worst-case probability of exceeding the VSAT emission envelope to one percent, not 0.001 percent.[43] In response, ARINC asserts that it assumed for purposes of its Monte Carlo simulations that all terminals transmit at the maximum return-link data rate of 128 kbps and thus that the results demonstrate that its system will keep aggregate e.i.r.p. density within the VSAT emission envelope at least 99.999 percent of the time without relying on the congestion control algorithm.[44]

27. Boeing also contends that ARINC's repeated assertion, in its report on the Monte Carlo simulations, that the SKYLink System will comply with the VSAT emission envelope 99.999 percent of the time is inconsistent with representations in the SKYLink application and the coordination agreement with SES and PanAmSat that aggregate earth-station off-axis e.i.r.p. density would be kept within a one-dB margin *below* the envelope 99.999 percent of the time.[45] In response, ARINC says that it refrained from mentioning the one-dB margin when discussing the simulations simply because Boeing's preceding

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[39] *Id.* at 4 and Exhibit 1 at 3-4.

[40] *Id.*, Exhibit 1 at 3.

[41] *Id.*, Exhibit 1 at 7.

[42] *Id.*, Exhibit 1 at 8. The formula that ARINC applied is $\mathbf{P}\,(\mathrm{EM}) = \sum_{K=0}^{N} \{\, \mathbf{P}\,(\mathrm{EM}|\,k) \bullet \mathbf{P}\,(k)\}$.

P(EM) is the probability of exceeding the mask, N is the number of logged-in terminals, k the number of simultaneously-transmitting terminals, **P**(EM| k) the probability of exceeding the mask given k simultaneous transmissions, and P(k) is the probability that k simultaneous transmissions occur with N logged-in AES terminals.

[43] Boeing Further Comments at 5; Technical Analysis filed as attachment to letter dated Sept. 30, 2004 to the FCC Secretary from Philip L. Malet and Carlos M. Nalda, Counsel to The Boeing Company ("Boeing 9/30/04 Technical Analysis"), at 2.

[44] ARINC Reply to Supplemental Comments, Exhibit 1 at 9; Response to Written Ex Parte filed Oct. 28, 2004 ("ARINC 10/28/04 Response") at 7.

[45] Boeing 9/30/04 Technical Analysis at 9.

comments focused entirely on compliance with the VSAT emission envelope itself.[46] ARINC reaffirmed that the SKYLink System "will be … operated so that it exceeds the mask minus 1 dB less than 0.001% of the time."[47]

28. Boeing further contends that ARINC's simulation-based assessment is defective because it is predicated on an assumption that SKYLink data traffic flow will be randomly distributed. Boeing contends that this assumption is unrealistic, asserting that TCP data-packet flow is "bursty" rather than randomly distributed.[48] More generally, Boeing contends that ARINC's reliance on predictive assumptions about traffic patterns is a fundamental flaw in its approach.[49] In response, ARINC maintains that although the data flow from individual SKYLink AES terminals may be bursty, the aggregate distribution of return-link traffic from active terminals in a full-CONUS SKYLink transponder footprint will, in fact, be essentially random.[50]

29. Boeing also contends that ARINC's probability assessment is skewed by miscalculation of antenna pointing error, mis-estimation of e.i.r.p. variation, and failure to consider the effect of forward-uplink transmission.[51] We address these contentions below under separate sub-headings.

30. The probability specification for the SKYLink System requires adherence to the VSAT emission envelope to a substantially greater extent than is required by the blanket waiver for random-access VSAT systems.[52] Yet, due to the use of spread-spectrum CDMA multiplexing for SKYLink return-link transmissions, peak aggregate off-axis e.i.r.p. density from multiple SKYLink AES operation will be substantially lower than a typical random-access VSAT network would generate if operating with the same probability of exceeding the VSAT emission envelope and much lower than the eight-dB-above-the-envelope limit that the Commission has proposed for contention-access VSAT systems that exceed the limit 0.001 percent of the time. We therefore conclude that SKYLink operation pursuant to the terms of the conditional authorization granted herein, pending adoption of service rules for Ku-Band AMSS, will not significantly increase the risk of harmful interference.

31. ARINC's predictive assumptions regarding terminal distribution, usage, and traffic flow generally seem reasonable, but in the event they prove inaccurate ARINC could nevertheless keep aggregate earth-station off-axis e.i.r.p. density within a one-dB margin below the VSAT emission envelope at least 99.999 percent of the time, as promised, by adjusting network-management algorithms governing log-ins, input power, return-link data rates, and duty cycles. ARINC will be required by the terms of its license to effect such adjustments, if necessary for conformance with the probability specification in its application and its uplink coordination agreement. To that end, the authorization granted herein includes a condition that will require ARINC to monitor usage patterns and traffic flow so

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[46] ARINC 10/28/04 Response at 10.
[47] *Id.*
[48] Boeing 9/30/04 Technical Analysis at 4-5.
[49] *Id.* at 6.
[50] ARINC 10/28/04 Response at 7.
[51] Boeing 9/30/04 Technical Analysis at 7-12.
[52] The blanket waiver indirectly constrains the probability of exceeding the envelope by authorizing continued use of existing techniques. Based on information provided by the licensee of a VSAT system using an Aloha contention protocol, the Bureau determined that the system's aggregate off-axis E.I.R.P. when operating with 38% channel loading would exceed the VSAT emission envelope by at least 3 dB for 4.9 percent of the time. *VSAT Blanket Waiver*, Appendix A, Sect. III.

that it can detect any material discrepancies from its previous predictive assumptions and to submit such information to the Commission for review. We believe that this suffices to resolve present concern about the ultimate validity of those assumptions.

32. We need not determine here whether keeping the aggregate off-axis e.i.r.p. density of SKYLink uplink transmission within a one-dB margin below the VSAT emission envelope 99.999 percent of the time is necessary to prevent harmful interference. The authorization granted here requires ARINC to operate in compliance with that restriction because ARINC has represented that that is what it will do. Although it might be inferred from certain statements in its pleadings that ARINC does not intend to ensure compliance with the 99.999% probability specification under all foreseeable circumstances, we do not construe the statements in that way because any such intention would be inconsistent with unequivocal representations in the SKYLink application. Nor do we construe any other specification in the application as overriding the commitment to keep the probability of exceeding the one-dB aggregate off-axis e.i.r.p. margin within 0.001 percent. Thus, for instance, if allowing 214 AES terminals to be logged in at the same time[53] would be inconsistent with that commitment, the authorization granted here does not permit it.[54]

2. Log-in Issues

33. Boeing contends that the SKYLink application is defective because it does not indicate how much power SKYLink AES terminals can radiate when transmitting log-in requests or whether there is a limit on the number of successive log-in bursts a terminal can transmit at maximum power.[55] Boeing also asserts that it is unclear how, if at all, the SKYLink NMS takes log-in transmissions into account when monitoring aggregate off-axis e.i.r.p. density.[56]

34. According to the application, the SKYLink NMS controls the log-in process by broadcasting a "bulletin-board" message at programmed intervals of a second or more.[57] A SKYLink AES terminal cannot transmit a log-in request (which is sent in a burst less than 20 milliseconds in duration) unless it has received and processed the bulletin-board message, which specifies various parameters for log-in transmissions, including an initial frequency range and available time-slots.[58] A terminal that has received the bulletin-board message can transmit a log-in request, in a data-burst less than 20 milliseconds in duration in one of the available time-slots chosen at random, under the direction of a search algorithm that requires use of minimum power for the initial request.[59] If the first attempt fails, the terminal will transmit a second request with different frequency parameters, still with minimum power.[60] If log-in attempts are persistently unsuccessful, the algorithm will instruct the terminal to

[53] *See* SKYLink Application, Exhibit 3 at 46.
[54] In the event the Commission adopts less-restrictive off-axis e.i.r.p. limits for Ku-Band AMSS systems with random-access protocols, ARINC will be free to seek relaxation of license restrictions in an application for modification of license.
[55] Boeing Comments at 7; Boeing Further Comments at 13.
[56] *Id.*
[57] SKYLink Application, Exhibit 3 at 7.
[58] ARINC Response, Exhibit 1 at 3; ARINC Reply to Supplemental Comments, Exhibit 1 at 11-12
[59] The initial power level is the minimum necessary to close a link under clear-sky conditions at the best possible location in the link budget analysis. ARINC Reply to Supplemental Comments, Exhibit 1 at 12.
[60] *Id*.

increase power successively in one-dB steps, as necessary, up to a specified maximum level.[61] An AES terminal that fails to log in after boosting power to the maximum extent[62] must cease further log-in attempts for a "quiet period" of a duration specified by the bulletin-board message.[63] The NMS will continually monitor the number of simultaneous AES transmissions, including log-in bursts, and will limit the probability of simultaneous log-in transmissions, insofar as necessary for compliance with aggregate earth-station off-axis e.i.r.p. restrictions, by adjusting the number of log-in time-slots, the frequency of repeat log-in attempts, the number of log-in attempts before a quiet period, and the length of the quiet period.[64] We conclude that ARINC has adequately addressed the concerns that Boeing raised with respect to log-in operation.

3. Control Lag

35. Boeing raised a question as to whether the SKYLink NMS would react quickly enough to prevent uplink interference from occurring. As noted previously, ARINC indicated in its application that the SKYLink NMS would control aggregate earth-station off-axis e.i.r.p. density by managing AES input power, data-transmission rates, and duty cycles, monitoring simultaneous transmissions, and limiting the number of logged-in terminals.[65] In subsequent comments, ARINC added that the NMS monitors the average number of simultaneous transmissions over successive 250-millisecond periods.[66] In light of this, Boeing asserts that there would be a half-second lag after the NMS determines that an adjustment is necessary before a remedial command signal would be received by logged-in AES terminals.[67] Boeing contends that the half-second lag-time would entail a significant potential for harmful interference.

36. Any AMSS system that relays signals via a satellite (or satellites) in geostationary orbit, including Boeing's and ARINC's, will be subject to inherent lag in reception of command signals from a ground-based network-management facility. However, ARINC can compensate for control lag, if necessary for compliance with the terms of its authorization, by adjusting NMS algorithms to afford an appropriate margin for error. Therefore, we do not believe that SKYLink operation pursuant to this authorization, pending adoption of pertinent AMSS service rules, will create a serious risk of harmful interference due to control lag.

4. Control of Malfunctioning Terminals

37. As previously noted, the SKYLink System relies on ground-based and on-board fault-management systems to detect and terminate aberrant AES operation. Boeing expressed concern

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[61] *Id.* at 13.

[62] ARINC asserts that the SKYLink login protocol "ensures that the maximum authorized AES power level [for login transmission] is no greater than necessary to close the link to the hub earth station under adverse conditions from the worst location in the link budget analysis." *Id.* at 13. We construe this to mean that the maximum possible on-axis e.i.r.p. for log-in transmission is 27.76 dBW, as specified in ARINC's link budget for 32 kbps uplink transmission from AES terminals in the vicinity of Bangor, Maine. *See* SKYLink Application, Technical Description at 25. Hence, the authorization granted herein does not permit log-in transmission with on-axis e.i.r.p. above 27.76 dBW under any circumstances.

[63] ARINC Reply to Supplemental Comments, Exhibit 1 at 12.

[64] ARINC Response at 7 and Exhibit 1 at 3.

[65] SKYLink Application, Exhibit 3 at 8-11.

[66] ARINC Response, Exhibit 1 at 2.

[67] Boeing Further Comments at 13.

regarding ARINC's ability to identify malfunctioning AES terminals, in view of the fact that they will be moving rapidly and transmitting intermittently in burst mode.[68] ARINC replied that its NMS can identify the source of an out-of-tolerance burst transmission because each return-link data-packet includes an IP address that uniquely identifies the transmitting terminal.[69] ARINC stressed, moreover, that a SKYLink AES terminal will self-mute if its built-in-test program detects a malfunction and that any malfunction that would prevent a terminal from decoding bulletin-board signals would also prevent it from transmitting.[70] ARINC contended that a single defective SKYLink terminal would be extremely unlikely to cause perceptible interference, in any event, as the maximum antenna flange power density that it could generate would be quite low.[71] Finally, ARINC said that in the unlikely event harmful interference occurs due to an undetected terminal malfunction, it would cooperate with affected satellite operators to identify the source by muting active SKYLink AES terminals one at a time until the interference ceases.[72] We conclude that these proposed fault-management measures are sufficient.

5. AES Duty Cycles

38. Boeing contended in its initial comments that the SKYLink application omitted "critical" information pertaining to control of AES duty cycles: *viz.*, whether the system controls the duty cycles of terminals that are attempting to log in, how the system controls AES duty cycles during "normal operation," what is the typical AES duty cycle, and how duty-cycle control is affected by constant-bit-rate traffic.[73] In subsequent comments ARINC explained in ample detail how the SKYLink NMS controls AES duty cycles during the log-in process.[74] ARINC has also explained that the NMS will control the duty cycles of logged-in terminals in a similar manner, by effectively specifying longer average time-intervals between successive burst transmissions when the number of simultaneous transmissions reaches a preset threshold.[75] We do not agree that ARINC has withheld crucial information in this regard.

6. Pointing Error

39. The parties debated in considerable detail the probable amount of average AES antenna pointing error and its effect on uplink interference potential. ARINC estimated in its application that root-mean-square ("RMS") average SKYLink AES pointing error would be less than one tenth of a degree.[76] ARINC maintains that even if average pointing error were somewhat larger it would have little impact on its system's aggregate e.i.r.p. density toward adjacent satellites, because the gain of a SKYLink AES antenna does not vary much within the relevant range of off-axis angles. For example, ARINC maintains that aggregate SKYLink e.i.r.p. density toward an adjacent satellite would not exceed the VSAT emission envelope even in the unlikely event that the antennas of all simultaneously-transmitting SKYLink AES terminals were mispointed by 0.6 degrees in that satellite's direction when the system is

[68] Boeing Comments at 8; Boeing Further Comments at 14.
[69] ARINC Response at 9.
[70] ARINC Reply to Supplemental Comments at 13.
[71] *Id*.
[72] *Id.* at 13-14.
[73] Boeing Comments at 8. AES duty cycle is the percent of the time an AES is transmitting. *See* ARINC Reply to Supplemental Comments at 9, n.13.
[74] *See* ¶34, *supra*.
[75] ARINC Response at 7; ARINC Reply to Supplemental Comments, Exhibit 1 at 6 and 9.
[76] SKYLink Application, Exhibit 3 at 16.

fully loaded.[77]

40. Boeing disputes ARINC's pointing-error estimate. Based on published standards for inertial-navigation-system accuracy, Boeing estimated that RMS-average pointing error for SKYLink AES terminals would be 0.59 degrees in azimuth and 0.38 degrees in elevation, with resultant cone error of 0.71 degrees.[78] ARINC contends that Boeing's estimate is useless because only pointing error in the plane of the geostationary satellite arc has any bearing on potential interference with co-frequency satellite systems and such error cannot be determined merely by calculating azimuth, elevation, and cone error.[79] In any case, ARINC asserts that it included Boeing's cone-error estimate among the factors modeled in its Monte Carlo simulation analysis, as previously reported.[80]

41. We agree with ARINC that Boeing's counter-estimate is irrelevant and conclude that ARINC has adequately accounted for pointing error.

7. Factors Affecting Terminal e.i.r.p.

42. *Transponder G/T Variation* In the application, ARINC indicated that its NMS continuously calculates the e.i.r.p. of each active AES terminal's transmissions based on the measured bit-energy/noise ratio at the hub earth station and the terminal's geographic position in relation to the satellite antenna's reception gain-to-noise-temperature ("G/T") contours.[81] ARINC later reported that it had allowed for G/T variation within a four-dB range in its simulation-based uplink interference analysis.[82] In response, Boeing contended that there is no mechanism in the SKYLink System that bars AES operation at locations where satellite reception G/T is more than 4 dB below the peak level and that terminals outside the four-dB-below-peak G/T contour might transmit at much higher e.i.r.p. levels than ARINC took into account in its analysis.[83] ARINC replied that, on the contrary, its analysis assumed that simultaneously-transmitting AES terminals are located where G/T is no more than four dB above the minimum value that defines the boundary of coverage.[84] ARINC maintained that the likelihood that a SKYLink AES terminal would transmit from a location outside the coverage-boundary G/T contour is statistically minimal, because typical spacecraft transmit and receive footprints are essentially co-extensive.[85]

43. Regardless of the assumptions on which ARINC predicated its interference analysis, ARINC will be obliged by the terms of this Order to ensure that the probability of exceeding a one-dB margin below the VSAT off-axis e.i.r.p. envelope does not exceed 0.001 percent and to demonstrate compliance with that requirement in actual operation. Such demonstration should disclose the extent, if any, to which the downlink footprint extends beyond the minimum G/T contour and explicitly account for consequent impact on aggregate e.i.r.p. Given that SKYLink AES terminals cannot attempt to log in without receiving a forward-link bulletin-board signal and must terminate logged-in transmission if they

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[77] ARINC Response, Exhibit 1 at 4. ARINC asserted that a pointing error of 0.6 degrees in the geostationary arc would increase e.i.r.p. toward an adjacent satellite by only one dB. *Id.*

[78] Boeing Further Comments at 14.

[79] ARINC 10/28/04 Response at 9.

[80] *Id*. *See* ARINC Reply to Supplemental Comments, Exhibit 1, Table 1.

[81] SKYLink Application, Exhibit 3 at 9.

[82] ARINC Reply to Supplemental Comments, Exhibit 1, Table 1.

[83] Boeing 9/30/04 Technical Analysis at 8.

[84] ARINC 10/28/04 Response at 9-10.

[85] *Id.* at 10.

lose the forward link for 250 milliseconds,[86] we infer that operation of SKYLink AES terminals at locations *outside* the downlink footprint will have negligible impact on aggregate e.i.r.p.

44. Rain Fade Boeing argued that ARINC's link budgets[87] do not take into account power increases to overcome rain fade in transmissions from AES terminals in aircraft on the ground.[88] In response, ARINC confirmed that the SKYLink System is designed to compensate for rain fade through uplink power control but maintained that power increases to overcome rain fade will be offset by the rain attenuation and therefore will not increase off-axis power flux-density at the geostationary satellite arc.[89] We agree with ARINC that power increases that merely compensate for rain fade will have no net effect on operation of co-frequency satellites.

45. Power-Control Error Boeing asserted in supplemental comments, without specific elaboration, that ARINC had not adequately accounted for the effect of errors in closed-loop power control on AES e.i.r.p.[90] ARINC later reported that it had allowed for a power-control error factor of ± 0.5 dB in its simulation-based uplink interference analysis.[91] The error allowance is plausible, and Boeing did not dispute it in subsequent pleadings. We therefore conclude that ARINC has sufficiently addressed Boeing's concern in this regard.

46. Calibration Error ARINC said in the application that it would use a reference transmitter co-located with the hub earth station, generating a waveform identical to the waveform of AES transmissions with an antenna conforming to the requirements of Section 25.209, to calibrate and monitor AES e.i.r.p.[92] Boeing maintained that ARINC should assess error factors associated with use of this technique, particularly inaccuracy of the calibration transmitter.[93] ARINC should address the concern about inaccuracy of the calibration transmitter in any future compliance showing required under the terms of its authorization.

8. Effect of Hub Transmission

47. ARINC uses a fixed Earth station with a 4.5-meter antenna, licensed to ViaSat, for forward uplink transmission. As mentioned previously, the hub station transmits in the same frequency band as the SKYLink AES terminals. Boeing contended that ARINC did not properly account for the contributing effect of hub transmission to aggregate earth-station off-axis e.i.r.p. density. Boeing maintained that if the hub station operates at the maximum input power permitted under the terms of ViaSat's license, it would generate off-axis e.i.r.p. only 3.4 dB below the VSAT emission envelope, leaving little margin for AES transmission.[94] ARINC maintained, however, that SKYLink hub transmission would have no appreciable effect on aggregate earth-station off-axis e.i.r.p., because the hub-station antenna has little pointing error, meets or exceeds the sidelobe-gain limits in Section 25.209, and operates with flange input power density of only -23 dBW/4kHz for SKYLink transmission, which is

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[86] *See* SKYLink Application, Exhibit 3 at 8.
[87] *See* SKYLink Application, Exhibit 3 at 24-41.
[88] Boeing Comments at 10, n.31.
[89] Response of ARINC, Nov. 28, 2003, Exhibit-1 at 4.
[90] Boeing Supplemental Comments at 16.
[91] ARINC Reply to Supplemental Comments, Exhibit 1 at 4.
[92] ARINC Response, Exhibit 1 at 4-5.
[93] Boeing Further Comments at 18-19.
[94] *Id.* at 19.

5.6 dB below the level authorized by ViaSat's license.[95] In response, Boeing argues that the Commission should not rely on ARINC's representations regarding the input power density of SKYLink hub transmission unless ViaSat's Earth-station license is modified to reduce the authorized power accordingly.[96]

48. We agree with ARINC that SKYLink hub earth-station transmission with input power at the level specified in its link budgets will have little effect on aggregate e.i.r.p. toward adjacent satellites. In the event hub input power exceeds that level, ARINC will be obliged to adjust network-control parameters as necessary to ensure compliance with the license restriction on aggregate earth-station off-axis e.i.r.p. density.

D. Coordination with Government Operation

49. The 14.0-14.2 GHz portion of the Ku-band is domestically allocated for secondary-status Federal-government operation in the Space Research Service ("SRS").[97] The National Aeronautics and Space Administration ("NASA") currently operates SRS Tracking and Data Relay Satellite System ("TDRSS") receive stations in White Sands, New Mexico, and Guam that operate in the 14.0-14.05 GHz band. NASA plans to establish an additional TDRSS receive facility on the east coast of the United States.[98]

50. The National Science Foundation ("NSF"), an independent Federal agency created by Congress, supports radio-astronomy observation in the 14.47-14.5 GHz band at National Radio Astronomy Observatories in New Mexico and West Virginia. The use of that band for radio-astronomy observation at those sites is recognized in Footnote US203 to the U.S. Table of Allocations, which requires steps to be taken to minimize interference with such operation from terrestrial radio transmitters. The NSF also supports radio-astronomy observation in the same band at various other sites in the continental United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

51. The Commission has proposed to require applicants for authority for AMSS operation in the 14.0-14.5 GHz band to coordinate with the NTIA to resolve concerns regarding interference with SRS and radio-astronomy operation, as a prerequisite for licensing.[99] In September 2004, ARINC filed copies of a signed coordination agreement with NASA pertaining to protection of TDRSS operation and a signed agreement with the NSF pertaining to protection of radio-astronomy observation.[100] In the NASA agreement, ARINC promised to monitor, control, and cease transmission of any SKYLink AES terminals that would exceed defined thresholds for protection of all current and future TDRSS Earth stations and to comply promptly with any request from NASA for help in identifying sources of transient interference that might have been caused by SKYLink operation. The coordination agreement with the NSF requires ARINC to shut down SKYLink AES terminals in line-of-sight with current and future NSF-supported radio-astronomy sites during periods of observation in the 14.47-14.5 GHz band and to limit the power

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[95] ARINC Response, Exhibit 1 at 4; ARINC Reply to Supplemental Comments, Exhibit 1 at 14-15; ARINC 10/28/04 Response at 10-13. ARINC asserted that the e.i.r.p. density of SKYLink hub transmission would be 30 dB below the VSAT envelope at two degrees off-axis. ARINC Reply to Supplemental Comments, Exhibit 1 at 15.

[96] Boeing 9/30/04 Technical Analysis at 11.

[97] *See* 47 C.F.R. § 2.106.

[98] *See Ku-Band AMSS NPRM* at ¶22.

[99] *Ku-Band AMSS NPRM* at ¶¶ 23 and 28.

[100] Letter with attachments from Carl R. Frank to the FCC Secretary dated Sept. 30, 2004.

flux-density of transmissions from individual AES terminals operating in the band 14-14.47 GHz to specified levels in the band 14.47-14.5 GHz at such sites during such periods of observation.[101]

52. The SKYLink AMSS authorization granted in this order is subject to a condition requiring the licensee to meet its obligations under the coordination agreements with NASA and the NSF. The authorization is also subject to a further condition that will require compliance with any pertinent additional requirements adopted in the Ku-Band AMSS rulemaking with respect to coordination or protection of Federal-government operation in the 14.0-14.5 GHz band.

E. Downlink Operation

53. The 11.7-12.2 GHz band is domestically allocated on a primary basis for FSS downlink transmission.[102] As the band is not currently allocated for AMSS, ARINC requested a waiver of the rule that spectrum use must be in accordance with the Table of Frequency Allocations, to permit 11.7-12.2 GHz downlink operation on a no-interference, non-protected basis.[103] ARINC also requested a waiver of Section 25.134(b) of the Commission's rules, which requires applicants for authority for digital downlink transmission in the 11.7-12.2 GHz band at e.i.r.p. densities above a specified threshold value to submit a detailed engineering analysis and prove by affidavit that all potentially-affected parties are aware of the proposed operation and have no objection. ARINC asserts that downlink transmission for the SKYLink System will comport with the limits for AMC-1 downlink operation established by coordination agreements between SES Americom and operators of adjacent satellites. No one filed comments in opposition to these waiver requests or raised any objection to ARINC's proposal with respect to downlink operation.

54. The Commission has previously granted Boeing authority for use of the 11.7-12.2 GHz band for AMSS downlink transmission from an existing FSS satellite. Because Boeing proposed to operate with peak downlink e.i.r.p. density in excess of the threshold value in Section 25.134(b), its downlink authorization was conditioned on submission of proof that operators of adjacent satellites had no objection.[104] There is no need to include such a condition on the downlink authorization in this instance, however, as the Commission has concluded that authority for digital downlink transmission in the 11.7-12.2 GHz band with e.i.r.p. density up to 10 dBW/4kHz should be routinely granted without

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[101] We note that ARINC's coordination agreement with the NSF includes a statement that the FCC has "accepted and implemented" the restrictions proposed in Recommendation ITU-R M.1643, Annex 1, Part C for protection of radio-astronomy observation in the 14.47-14.5 GHz band. The statement is incorrect. Although the International Bureau has inserted conditions in AMSS authorizations, including the authorization granted by this order, based on ITU-R M.1643 and preceding preliminary draft recommendations, the Commission has not "accepted and implemented" Annex 1, Part C of the Recommendation. Rather, the Commission has proposed adoption of a rule that would require coordination with the NTIA regarding impact on radio-astronomy observation in the 14.47-14.5 GHz band as a prerequisite for licensing 14 GHz AMSS operation. *See Ku-Band AMSS NPRM* at ¶28. The Commission is not a party to the ARINC/NSF agreement. Our action in this order is without prejudice to action by the Commission in the pending Ku-Band AMSS rulemaking.

[102] *See* 47 CFR § 2.106 and Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands, IB Docket No. 02-10, *Report and Order*, FCC 04-286 (rel. Jan. 6, 2005) at ¶79.

[103] *See* 47 CFR § 2.102(a).

[104] *Boeing 12 GHz License Order* at ¶10.

requiring coordination,[105] and as ARINC indicates in its application that the e.i.r.p. density of downlink transmissions for the SKYLink System will not exceed 7.96 dBW/4kHz.[106] We therefore grant the requested authority for downlink operation in the 11.7-12.2 GHz band.

F. Performance Verification

55. Boeing points out that its authorization for AMSS operation in the 14.0-14.5 GHz band was granted subject to a condition that required it to file, at least sixty days prior to commencing commercial operation, a report demonstrating with test data that its system would operate in compliance with the terms of the authorization.[107] Boeing contends that any authorization for SKYLink operation granted prior to adoption of pertinent AMSS service rules should include a similar condition.[108] In response, ARINC maintains that it was appropriate to include the verification condition in Boeing's 14 GHz authorization because the authorization was granted at a time when there was no international or domestic allocation for 14 GHz AMSS operation. ARINC contends that there is no need for such a condition now that the ITU and the Commission have both adopted secondary allocations for AMSS uplink transmission in the 14.0-14.5 GHz band.[109]

56. Although the 14.0-14.5 GHz band is now allocated for AMSS, the fact remains that ARINC is requesting a grant of authority for SKYLink operation in advance of adoption of pertinent service rules. Moreover, ARINC's uplink interference analysis is partly based on predictive assumptions that may prove inconsistent, to some degree, with conditions encountered in full-scale commercial operation. Under these circumstances, we believe that it is appropriate to condition the SKYLink authorization on a requirement to submit proof of compliance with uplink performance specifications. We are not requiring submission of a further showing prior to commencement of commercial operation in this instance, because the SKYLink System has already commenced commercial operation under an experimental license. Data obtained after ARINC has had an opportunity to expand commercial operation pursuant to this authorization, moreover, would be more useful than data on operation to date on the limited basis previously allowed. The authorization granted herein is therefore conditioned on submission of a report one year after the release-date of this order demonstrating continuing compliance with the license restriction on aggregate earth-station e.i.r.p. density toward the geostationary-satellite orbital arc.

IV. CONCLUSION

57. We find, pursuant to Section 309 of the Communications Act, 47 U.S.C. § 309, that grant of authority for operation of the SKYLink System as conditioned herein will serve the public interest, convenience, and necessity.

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105 *See Fifth Report and Order in Docket 00-248* at ¶¶ 93-95.

106 SKYLink Application, Exhibit 3 at 19.

107 *See Boeing 14 GHz License Order* at ¶19(h)(5).

108 Boeing Comments at 14; Boeing Further Comments at 20-21; Letter from Philip L. Malet and Carlos M. Nalda, Counsel to The Boeing Company, to the FCC Secretary dated Sept. 30, 2004, at 2.

109 Letter dated Oct. 28, 2004 from Carl R. Frank, Counsel for ARINC, to the FCC Secretary dated Oct. 28, 2004, at 7-8.

V. ORDERING CLAUSES

58. Accordingly, IT IS ORDERED that Application File No. SES-LIC-20030910-01261 and SES-AMD-20031223-01860 IS GRANTED and ARINC Incorporated IS AUTHORIZED to operate up to one thousand technically-identical transmit/receive mobile Earth stations aboard aircraft, operating with the AMC-1 satellite at the 103ºW.L. orbital location, in the 11.7-12.2 GHz and 14.0-14.5 GHz bands in the United States and in airspace above U.S. territorial waters, in accordance with the terms and specifications in its application and applicable rules of the Commission, except insofar as waived herein, and subject to the following conditions.

a) The SKYLink System shall operate in compliance with any pertinent rule requirements subsequently adopted by the Commission.

b) SKYLink AES terminals will employ a tracking algorithm that is resistant to capturing and tracking adjacent satellite signals, and each AES terminal will be capable of inhibiting its own transmission in the event it detects unintended satellite tracking.

c) SKYLink AES terminals will be monitored and controlled by a ground-based network control center. Each SKYLink AES terminal will be able to receive "enable transmission" and "disable transmission" commands from the network control center and will cease transmission immediately after receiving any "parameter change" command until it receives an "enable transmission" command from the network control center. The network control center will monitor operation of each SKYLink AES terminal to determine if it is malfunctioning, and each SKYLink AES terminal will self-monitor and automatically cease transmission on detecting an operational fault that could cause harmful interference to FSS networks.

d) SKYLink operation in the 11.7-12.2 GHz band shall be in accordance with the space-station authorization for the AMC-1 satellite and shall not generate e.i.r.p. density greater than 7.96 dBW/4kHz.

e) ARINC, as a non-conforming user, must accept interference from lawful operation of any station authorized to operate in the 11.7-12.2 GHz band in accordance with the U.S. Table of Allocations (47 C.F.R. § 2.106) and shall immediately terminate SKYLink System operation upon notification that such operation is causing harmful interference, not permitted under the terms of a pertinent coordination agreement, with lawful operation of any radio system in the 11.7-12.2 GHz band authorized in conformance with the U.S. Table of Allocations.

f) ARINC shall immediately terminate SKYLink System operation upon notification that such operation is causing harmful interference, not permitted under the terms of a pertinent coordination agreement, with lawful operation of any system in the 14.0-14.5 GHz band authorized on a primary basis in conformance with the U.S. Table of Allocations or authorized previously on a secondary basis.

g) ARINC shall maintain a point of contact for discussing interference concerns with other licensees, NASA, and NSF, and shall submit a letter to be included in its license file with the name and telephone number of the contact within 30 days of the release of this *Order*.

h) ARINC shall not use the SKYLink System for air traffic control communications.

i) ARINC shall comply with any pertinent limits established by the International Telecommunication Union ("ITU") to protect other services allocated internationally.

j) Operation pursuant to this authorization shall conform to the requirements of ARINC's coordination agreements with NASA and the NSF and its coordination agreement with PanAmSat and SES Americom.

k) ARINC shall manage uplink operation of the SKYLink System so that the probability that aggregate earth-station off-axis e.i.r.p. spectral density will exceed a one-dB margin below the levels specified in the table below is never more than 0.001 percent. To ensure continuing compliance with this requirement, ARINC shall monitor usage patterns and traffic flow so that it can detect and adjust for any material discrepancies from the predictive assumptions identified in the exhibit to its Reply to Supplemental Comments of The Boeing Company filed on June 3, 2004.

Angle off-axis	Maximum e.i.r.p. in any 4 kHz band
$1.25^\circ \leq \theta \leq 7.0^\circ$	$15 - 25\log_{10}\theta$ dBW
$7.0^\circ < \theta \leq 9.2^\circ$	-6 dBW
$9.2^\circ < \theta \leq 48^\circ$	$18 - 25\log_{10}\theta$ dBW
$\theta > 48^\circ$	-24 dBW

l) Twelve months after release of this order, ARINC shall submit evidence demonstrating compliance with the aggregate earth-station off-axis e.i.r.p. restriction specified in the preceding sub-paragraph. The showing shall reflect the most-recent available data and shall disclose any discrepancies between previous predictive assumptions and conditions actually encountered in commercial operation and explain what compensating adjustments have been made.

59. IT IS FURTHER ORDERED that ARINC IS GRANTED a waiver of Section 2.106 of the Commission's rules with respect to operation of the SKYLink System in the 11.7-12.2 GHz band consistent with the terms of this authorization.

60. ARINC may decline this authorization as conditioned within 30 days from the date of release of this *Order and Authorization*. Failure to respond within that period will constitute formal acceptance of the authorization as conditioned.

61. This *Order and Authorization* is issued pursuant to Sections 0.241 and 0.261 of the Commission's rules on delegated authority, 47 C.F.R. §§ 0.241, 0.261, and is effective upon release.

FEDERAL COMMUNICATIONS COMMISSION

Donald Abelson
Chief, International Bureau

Edmond J. Thomas
Chief, Office of Engineering and Technology