

The Boeing Company
Experimental Modification Application
Description and Technical Information

I. INTRODUCTION

As the Commission is aware, Boeing has ceased providing Aeronautical Mobile-Satellite Service (“AMSS”) service to commercial customers and is now providing service to U.S. Government users only. In light of this fundamental change to the service, Boeing intends to surrender blanket license Call Sign E000723 and rely exclusively on its experimental license for authority to conduct experimental AES operations and provide service pursuant to government contract within the United States and in international and foreign airspace, as currently authorized by Call Sign WC2XVE. Boeing will continue to conduct its experimental AMSS operations on a non-harmful interference basis and consistent with the other conditions set forth in its experimental license. Accordingly, Boeing seeks to update its experimental authority to facilitate the provision of aeronautical broadband services to U.S. Government users.

Specifically, The Boeing Company (“Boeing”) seeks to modify or otherwise update its experimental AMSS license Call Sign WC2XVE (File No. 0254-EX-RR-2006) in the following ways:

- (i) to ensure that the 1 dB “cushion” imposed on aircraft earth station (“AES”) operations with the AMC-4 satellite by blanket AES license Call Sign E000723 (File No. SES-MOD-20020308-00429) issued by the International Bureau (“Bureau”), and the associated order granting Boeing transmit/receive authority for its AMSS system jointly issued by the Bureau and the Office of Engineering and Technology (“OET”),^{1/} will not apply to future operations;

^{1/} The Boeing Company, *Order and Authorization*, 16 FCC Rcd. 22645 (2001) (“*Transmit-Receive Order*”).

(ii) to ensure that AESs located outside the United States and communicating with satellites in a non-2 degree spacing environment may continue to operate at aggregate off-axis e.i.r.p. levels consistent with the coordinated parameters of the serving satellites;

(iii) to confirm Boeing's experimental AES operations will comply with coordination agreements with the National Science Foundation and NASA;

(iv) to specify individual satellite points of communication in lieu of the "ALSAT Ku" designation currently included in the authorization; and

(v) to add a new emission designator for AES transmissions.

These modifications will enable Boeing to provide more efficient and cost-effective service to U.S. Government users, ensure continued interference-free experimental operations and conform Boeing's experimental license to Commission guidelines associated with use of the "ALSAT" designation.

The general public interest considerations supporting grant of Boeing's experimental modification application have been set forth in detail in the various applications associated with Call Sign WC2XVE, which are hereby incorporated by reference. At base, grant of Boeing's modification application would strongly serve the public interest by enhancing the efficiency and cost effectiveness of the Boeing's AMSS operations and affording U.S. Government users continued access to critical aeronautical broadband communications services. Expedited consideration of Boeing's application is requested to realize these important benefits at the earliest practicable time.

II. LICENSING BACKGROUND

International Bureau. On December 21, 2001, Boeing was authorized by the Commission to operate up to 800 technically identical transmit/receive phased-array AESs aboard aircraft communicating with the Telstar 6 satellite (now Intelsat's Galaxy 26 satellite,

which Boeing no longer uses) to provide AMSS services in Ku-band frequencies.^{2/} The Commission authorized Boeing's AMSS operations in the 11.7-12.2 GHz (downlink) and 14.0-14.5 GHz (uplink) bands on an unprotected, non-harmful interference basis (*i.e.*, a "non-conforming" use) in the United States, including the airspace above U.S. territorial waters, subject to certain conditions.^{3/} In 2002, the Commission granted an application to modify Boeing's license to add the Americom 4 (now AMC-4) satellite at 101° W.L. as an authorized point of communication, subject to the same geographic and operational restrictions set forth in the *Transmit-Receive Order*.^{4/} Subsequent modification to the Boeing license allowed for the addition of new antennas types and emissions designators.^{5/}

In the Transmit-Receive Application, Boeing proposed that the aggregate off-axis e.i.r.p. spectral density of simultaneously transmitting AESs would not exceed a 1 dB margin below the levels specified for routinely licensed VSAT earth stations.^{6/} This 1 dB "cushion" was included to provide an extra margin of assurance that Boeing's new commercial AMSS system would operate at or below the VSAT emission envelope, and thus not cause harmful interference to

^{2/} See The Boeing Company, FCC File No. File No. SES-LIC-20001204-02300, Radio Station License Call Sign E000723; See also *Transmit-Receive Order*, 16 FCC Rcd. at 22653-55 ¶¶ 19-22.

^{3/} See *id.* The Commission defined "territorial waters" as extending 12 nautical miles from the coastlines of the United States. *Id.* at 22653 ¶ 19 n.62.

^{4/} See The Boeing Company, FCC File No. SES-MOD-20020308-00429, Call Sign E000723 (granted Sept. 26, 2002).

^{5/} See The Boeing Company, FCC File No. SES-MOD-20030512-00639, Call Sign E000723 (granted Nov. 14, 2003); The Boeing Company, FCC File No. SES-MFS-20050701-00853, Call Sign E000723 (granted Dec. 20, 2005).

^{6/} Application of The Boeing Company for Blanket Authority to Operate Up to Eight Hundred Technically Identical Transmit and Receive Mobile Earth Stations Aboard Aircraft in the 11.7-12.2 and 14.0-14.5 GHz Frequency Bands, File No. SES-LIC-20001204-02300. at 3-5, 10-17 (filed Dec. 4, 2000, supplemented Jan. 10, 2001) ("Transmit-Receive Application").

adjacent satellite operators. The licensing approach taken in the *Transmit-Receive Order* therefore included (i) a limit on the aggregate off-axis e.i.r.p. spectral density of simultaneously transmitting AESs in addition to an individual AES transmit power limit; and (ii) an aggregate limit set at a 1 dB margin below the levels specified for routinely licensed VSAT earth stations.^{7/} Significantly, the limit applies only to Boeing's domestic AMSS operations with the AMC-4 satellite because the *Transmit-Receive Order* and associated blanket license does not include authority for operations outside the United States. In addition, Boeing would note that it obtained temporary relief from the 1 dB "cushion" requirement and there were no reported incidents of interference, but uncertainty with respect to other requirements of the new authorization eventually lead to reinstatement of Boeing's original operating condition.^{8/}

OET. Boeing separately obtained a series of experimental licenses to support domestic experimentation, as well as Boeing's international AES operations in connection with the provision of critical AMSS services to U.S. Government customers pursuant to government contract. Boeing continues to provide service to the U.S. Government under government contract^{9/} and is also authorized to conduct limited land mobile operations pursuant to this authority (File No. 0038-EX-ML-2003).

^{7/} See The Boeing Company, FCC File No. SES-MFS-20050701-00853, Radio Station License Call Sign E000723 at Special Condition 5411.

^{8/} See *id.*; The Boeing Company, FCC File No. SES-STA-20060119-00067, Call Sign E000723 (granted Jan. 20, 2006).

^{9/} Boeing has a contract with the U.S. Air Force Materiel Command ("AFMC"), Contract No. F33657-01-D-0013, to provide, among other things, broadband communications to U.S. Government aircraft. Pursuant to this contract, Boeing has provisioned phased-array antennas on thirteen VIP/SAM (Very Important Personnel/Special Air Mission) aircraft operated by the U.S. Air Force Air Mobility Command to transport senior leadership of the U.S. Government and the Department of Defense.

Boeing's experimental license WC2XVE does not include the 1 dB "cushion" imposed by the *Transmit-Receive Order* and AES blanket license. The experimental authorization limits the transmit power of individual AESs rather than the aggregate off-axis e.i.r.p. of simultaneously transmitting AESs. Consistent with the experimental license, and with Recommendation ITU-R M.1643 governing AMSS operations,^{10/} all authorized international operations of AESs installed on U.S. Government aircraft have been limited to the coordinated parameters of the serving satellites. Boeing AESs installed on foreign-registered aircraft also operated internationally without the 1 dB "cushion" and consistent with the coordinated parameters of the serving satellite. No instances of harmful interference were ever observed from these operations.

III. ELIMINATION OF THE 1 DB "CUSHION" FOR DOMESTIC AES OPERATIONS WOULD SERVE THE PUBLIC INTEREST

Since grant of its transmit-receive authorization in 2001, Boeing has gained substantial experience in operating its AMSS system and fully accounting for the variables that affect off-axis e.i.r.p. produced by AES transmissions. Boeing has affirmatively demonstrated its ability to control AES off-axis e.i.r.p. within the limits for routinely licensed VSATs in the context of its AES applications and two post-grant performance verification reports.^{11/} Boeing's successful

^{10/} See Recommendation ITU-R M.1643 at Annex 1, Part A.

^{11/} See Boeing AMSS System License Compliance Report, FCC File No. SES-LIC-20001204-02300, Call Sign 000723 (filed Aug. 14, 2002) ("Compliance Report"); Boeing AMSS System License Compliance Report - Reflector Antenna AES Update, FCC File No. SES-LIC-20030512-00639, Call Sign 000723 (filed Feb. 12, 2004) ("Second Compliance Report"). The Second Compliance Report was filed in response to a special condition imposed by the Commission pursuant to a conservative interpretation of the testing and reporting requirements set forth in the *Transmit-Receive Order*. See The Boeing Company, FCC File No. SES-MOD-20030512-00639, Call Sign E000723 (granted Nov. 14, 2003) at Special Condition 5948.

control of AES is confirmed by the interference-free operation of its AMSS system from the time it was originally authorized by the Commission, including operations outside the United States at aggregate off-axis e.i.r.p. levels up to the coordinated levels of the serving satellites, as well as operations within the United States during the limited period when the 1 dB “cushion” was not in force domestically. Throughout this entire period, Boeing has never received a reported case of harmful interference.

A. Removal of the 1 dB “Cushion” Will Not Result In Harmful Interference

As demonstrated in the attached technical exhibits, the Boeing AMSS system actually controls its aggregate off-axis e.i.r.p. density to a confidence level many times greater than the 99.99% level specified in its application and authorized by the Commission. This conclusion is confirmed by actual operational data over a ten-day period in January 2006 when the AMSS system was operating within an aggregate off-axis e.i.r.p. density equivalent to the routine VSAT mask. The operational data shows that off-axis e.i.r.p. control levels were many times better than 99.99% and the duration and magnitude of calculated exceedances were extremely small.^{12/} This performance is orders of magnitude better than existing VSAT and ESV networks, particularly when considering the Commission’s proposal to permit VSAT systems to exceed permissible power levels by various amount for certain percentages of time.^{13/} In addition, Boeing’s detailed

^{12/} See Off-Axis E.I.R.P. Utilization and Control Exhibit at 1-2 (attached hereto); *see also* Aggregate Off-Axis E.I.R.P. Spectral Density Testing Exhibit (attached hereto).

^{13/} See Off-Axis E.I.R.P. Utilization and Control at 1. For example, TDMA and FDMA VSAT and earth stations onboard vessel (“ESV”) systems produce off-axis e.i.r.p. density levels equivalent to the permissible mask, but do not factor mispointing into their permissible power level. Thus, while they comply with the mask, the actual off-axis e.i.r.p. density levels received by adjacent satellites exceeds the mask in proportion to the level of mispointing. In contrast, the Boeing AMSS system continuously calculates the aggregate off-axis e.i.r.p. density level produced by the system to a 99.99% confidence level and includes variables such as mispointing to set permissible AES power levels.

description of its current network control, testing and simulation programs, as well as simulations of system performance in various operational scenarios, confirms that the AMSS system will continue to operate as designed and in an interference-free manner.^{14/}

Boeing also continuously monitors the actual system performance to ensure that the control and monitoring algorithms perform as expected. For example, during the first nine weeks of 2007, the algorithms identified only a small number of instances in which the calculated aggregate off-axis e.i.r.p. spectral density (computed based on the parameters reported by AESs to the ground) exceeded the target criteria -- 1 dB below the Ku-band VSAT routine licensing limits. Each of these exceedances was corrected within 1 second, resulting in a compliance level of 99.9997%. This is several orders of magnitude better than the required 99.99%, and many orders of magnitude better than the performance of VSAT and ESV systems that operate in this band. Although system performance already exceeds the Commission's requirements by a wide margin, Boeing also carries out root cause analysis whenever a calculated exceedance occurs to determine why it occurred and whether system performance could be improved.^{15/}

Moreover, the occurrence of a calculated exceedance does not mean that the emissions from the aircraft actually exceeded the interference level criteria. Given Boeing's aggregate power management algorithm, for each of these calculated instances there was a 99.99% probability that the actual off-axis e.i.r.p. spectral density was less than the computed amount. Because of the extreme conservatism of this approach, most of the time an actual exceedance does not occur.

^{14/} See *id.* at 7-15.

^{15/} See Aggregate Off-Axis E.I.R.P Spectral Density Analysis (Mar. 21, 2007) (attached hereto).

In view of the foregoing, OET can conclude with certainty that the Boeing AMSS system can protect adjacent satellites from harmful interference at least as well as, if not better than, other systems that are permitted to operate at the routine VSAT level; and that permitting Boeing to operate at that level domestically, as it has operated successfully outside the United States, would not increase the potential for harmful interference to other users of the spectrum.

B. Removal of the 1 dB “Cushion” Will Have Other Important Benefits

The inclusion of a 1 dB cushion results in a 26% reduction of the spectral efficiency of the Boeing AMSS system. Thus, eliminating the cushion would enable the system to utilize spectrum far more efficiently. Of course, enhancing spectrum efficiency is an important Commission objective found repeatedly to be consistent with the public interest.^{16/}

Further, the enhanced capacity afforded by removal of the 1 dB “cushion” will permit Boeing to utilize fractional transponders for its AMSS service to U.S. government users. Use of fractional rather than full transponders for U.S. domestic service will result in cost savings totaling hundreds of thousands of dollars annually in transponder procurement costs. Because the Boeing AMSS system effectively controls the aggregate off-axis emissions of simultaneously transmitting AESs, these cost savings and increases in spectrum efficiency come at no risk of interference to co-frequency operators.

^{16/} See Federal Communications Commission, Fiscal Year 2006 Performance and Accountability Report at 4 (Nov. 15, 2006) (“Efficient and effective use of non-federal spectrum domestically and internationally promotes the growth and rapid deployment of innovative and efficient communications technologies and services.”); *see also* Federal Communications Commission Spectrum Policy Task Force, ET Docket No. 02-135, Report of the Spectrum Efficiency Working Group at 4 (Nov. 15, 2002) (“...most “prime” spectrum has been assigned, and it is becoming increasingly difficult to find spectrum that can be made available either for new services or to expand existing ones. To ensure that existing services can continue to grow and evolve to serve marketplace needs, and that new services have a chance to blossom and grow, it is important that the Commission continue to promote efficient access to and use of the radio spectrum.”).

C. Options for Removing the 1 dB “Cushion”

In view of the foregoing, Boeing requests confirmation that it may control the aggregate off-axis e.i.r.p. levels produced by the AESs located in the United States to the same level as a routinely licensed VSAT earth station (*i.e.*, remove the 1 dB cushion). From an experimental licensing perspective, there are two primary means by which this may be done.

First, since Boeing’s current experimental authorization does not limit aggregate off-axis e.i.r.p., OET could confirm that the 1 dB “cushion” would become ineffective upon surrender of Boeing’s AES blanket license and rely on existing special conditions requiring Boeing to operate on a non-harmful interference basis consistent with satellite operator coordination agreements. Because the satellite operator certification for AMC-4 submitted with this application confirms that Boeing’s AES operations are consistent with the Commission rules establishing maximum off-axis e.i.r.p. levels in the 14.0-14.5 GHz band, OET need not separately specify aggregate off-axis e.i.r.p. levels in the authorization. This approach avoids unnecessary additional conditions and has the added benefit of covering AES operations both inside and outside the United States.

Alternatively, OET could include as special condition of the experimental license the aggregate off-axis e.i.r.p. mask included in Special Condition 5411 of Boeing’s blanket AES license.^{17/} However, specifying aggregate off-axis e.i.r.p. levels for domestic AES operations would require specifying separate, higher aggregate off-axis e.i.r.p. levels that are presently authorized under Boeing’s experimental license for AES operations outside the United States.^{18/}

^{17/} See Radio Station License Call Sign E000723 (File No. SES-MFS-20050701-00853) at Special Condition 5411.

^{18/} This could be done by replicating the off-axis e.i.r.p. mask using higher values, or specifying that AESs may operate outside the United States at an aggregate off-axis e.i.r.p. levels 8 dB higher than those included in the special condition governing domestic AES operations.

Boeing believes that the first option is preferred given its simplicity and consistency with current regulation of Boeing's experimental operations outside the United States. However, either approach would afford Boeing the necessary authority to operate domestically without the 1 dB "cushion."

IV. AESs LOCATED OUTSIDE THE UNITED STATES SHOULD CONTINUE TO OPERATE CONSISTENT WITH THE COORDINATED PARAMETERS OF THE SERVING SATELLITES

Boeing also seeks to ensure that AESs located outside the United States and communicating with satellites in a non-2 degree spacing environment may continue to operate at aggregate off-axis e.i.r.p. levels consistent with the coordinated parameters of the serving satellites. As discussed above, Boeing's existing experimental authorization does not limit AES operations to a specific aggregate off-axis e.i.r.p. level, but rather limits AES operations to the coordinated parameters of the serving satellites. Thus, Boeing currently operates AESs onboard U.S. Government aircraft at aggregate off-axis e.i.r.p. levels greater than the 2-degree spacing levels. There has never been a reported case of interference resulting from these operations.

Continuation of Boeing's international AES operations under current operating parameters would serve the public interest. Boeing controls AES emissions to a confidence level that is orders of magnitude greater than other Ku-band systems. Thus, there is no risk of harmful interference to other users of the band. Moreover, extending Boeing's existing international operating authority will maintain the efficiency and geographic reach of those operations, to the benefit of U.S. Government users. In view of Boeing's long record of interference-free AES operations, there is no basis to alter the aggregate off-axis e.i.r.p. levels at which Boeing's AMSS system operates.

As noted above, OET need not modify the conditions of Boeing's experimental authorization because it currently permits AES operations consistent with the coordinated parameters of the serving satellites. If, however, OET chooses to impose an aggregate off-axis e.i.r.p. mask for domestic AES operations in the context of removing the 1 dB "cushion" (see Section III, *supra*), it must also specify an aggregate off-axis e.i.r.p. mask that is 8 dB higher for international AES operations in order to maintain Boeing's existing authority.

V. BOEING'S EXPERIMENTAL AES OPERATIONS WILL COMPLY WITH COORDINATION AGREEMENTS WITH NSF AND NASA

Because certain operating requirements were imposed in the context of Boeing's commercial AMSS operations by the *Transmit-Receive Order* and AES blanket license, it is not clear that they survive surrender of that operating authority. Accordingly, Boeing confirms that it will continue to meet the stated parameters necessary to protect NASA's TDRSS operations, as well as U.S. Radio Astronomy stations observing in the 14 GHz band, as set forth in the applicable agreement and letter referenced in the *Transmit-Receive Order*.^{19/} Boeing further confirms that it will operate its aircraft earth stations aboard U.S. aircraft traveling outside the United States in accordance with the internationally accepted levels for protecting Fixed Service ("FS") stations when operating co-frequency with FS to the extent required by foreign administrations or otherwise required by the international Radio Regulations.

^{19/} See *Transmit-Receive Order*, 16 FCC Rcd. at 22647-48 ¶ 6 & nn.20-21 (citing Technical Operational Coordination Agreement for the Joint Usage of the Band 14.0-14.5 GHz Between the National Science Foundation and Aircraft Earth Stations Operating in the Boeing Connexion Aeronautical Mobile Network, Version 3.1 (Dec. 13, 2001) and Letter from Robert E. Spearing, Deputy Associate Administrator for Space Communications, Office of Space Flight, NASA, to Craig Holman, Regulatory Counsel, The Boeing Company (Dec. 18, 2001)).

OET may seek to expressly condition grant of modified experimental authority on compliance with these requirements, or otherwise require Boeing to operate in accordance with the parameters set forth in this modification application.

VI. SPECIFYING BOEING’S AUTHORIZED POINTS OF COMMUNICATION WOULD BE CONSISTENT WITH THE COMMISSION’S ALSAT RULES

Boeing is authorized by the Commission to operate on an experimental basis a total of 30 AESs^{20/} aboard U.S.-registered aircraft communicating in the 14-14.5 GHz band with ALSAT Ku-band satellites (*i.e.*, U.S. licensed satellites and those foreign-licensed satellites on the Permitted Space Station List), as well as the SESAT, Superbird-C and AsiaSat 3S satellites, over CONUS, Alaska and Hawaii and in international airspace. Boeing seeks to specify the individual satellites with which it currently communicates under the “ALSAT Ku” designation. Specifically, Boeing seeks to include the AMC-4, AMC-23, Intelsat 907 and Estrela do Sul satellites in its experimental authorization in lieu of “ALSAT Ku.” The first three satellites are licensed by the Commission, and the last satellite is on the Permitted Space Station List.^{21/}

Boeing initially applied for ALSAT authority in its first AMSS experimental application, and this designation has been retained through subsequent renewals and modifications. However, the ALSAT designation is generally reserved for primary Fixed-Satellite Service (“FSS”) applications operating in conventional Ku-band frequencies. Although Boeing communicates with FSS satellite transponders in conventional Ku-band uplink frequencies, its experimental AMSS stations must operate on a non-harmful interference basis vis-à-vis primary FSS services. Thus, continued reliance on the ALSAT designation may not be appropriate.

^{20/} Boeing is authorized to simultaneously operate up to ten (10) phased-array antennas, ten (10) next-generation reflector and ten (10) smaller business jet reflector antennas.

^{21/} Thus, there is a presumption that access to the Estrela do Sul satellite would serve the public interest.

Importantly, Boeing is already communicating with the specified satellites and has never had a reported case of harmful interference. Continued communications with all of these satellites for critical U.S. Government services would serve the public interest and is necessary to maintain the geographic scope of Boeing's experimental operations. Furthermore, Boeing does not seek to alter any operational conditions set forth in its experimental licenses to permit communications with these satellites. Boeing recognizes and accepts the existing conditions, and confirms that it will operate its experimental stations in accordance with the interference levels that have been accepted by other satellites in coordination with these authorized points of communication. In the connection, Boeing has included certification letters from the satellite operators confirming compliance with relevant coordination agreements. As a result, Boeing's experimental AES operations will continue to be conducted in a manner that protects other users of the 14.0-14.5 GHz band from potential harmful interference.

VII. ADDING A NEW EMISSION DESIGNATOR WOULD ENHANCE THE EFFICIENCY OF BOEING AMSS OPERATIONS

In order to reduce the cost of providing AMSS service to U.S. Government users and enhance operational flexibility, Boeing intends to use fractional transponder leases to obtain Ku-band FSS satellite capacity. Accordingly, Boeing seeks to add a new emission designator with a narrower bandwidth for use with all authorized satellite points of communication. Specifically, Boeing hereby requests authority to add emission designator 3M4G7D for return link (AES uplink) transmissions.

This new emission designator is compliant with the coordinated interference levels of the Ku-band satellites with which Boeing's AESs will communicate. In addition, Boeing will continue to manage the aggregate transmit off-axis e.i.r.p spectral density of simultaneously

transmitting AESs so that it remains within the levels accepted by adjacent satellite operators.^{22/}

Accordingly, Boeing's requested modification to include the additional emissions designator will have no adverse impact on other users of the Ku-band.

VIII. CONCLUSION

For all of the foregoing reasons, Boeing respectfully requests OET to modify or otherwise update its experimental license Call Sign WC2XVE in a manner consistent with this experimental modification application.

^{22/} Although not expressly regulated by OET, Boeing will also limit the downlink power spectral density for each satellite within the accepted limits for every emission designator.