The Boeing Company
Experimental Modification Application
FCC Form 442, Exhibit 1

NARRATIVE STATEMENT

The Boeing Company ("Boeing") requests that the Commission modify Boeing's existing experimental license to operate Aeronautical Mobile-Satellite Service ("AMSS") terminals in the 14.0-14.5 GHz band to add a new aircraft earth station ("AES") antenna.[1] Specifically, Boeing seeks authority to conduct experimental operations with up to ten (10) technically identical mechanically steered horn-lens antennas at its system integration facility ("SIF") in Kent, Washington, and mounted on aircraft operating throughout the United States (including Alaska and Hawaii) and in international airspace. These new AES antennas will be tested in connection with providing broadband communications capabilities to aircraft of various sizes, including smaller general aviation aircraft, in a new service offering called eXchange.

As demonstrated herein, modifying Boeing's experimental authorization to add the eXchange AES antenna would not increase the potential for interference into other services from Boeing's experimental operations, and would facilitate the provision of broadband AMSS services to the passengers and crew of smaller aircraft. As a result, grant of this experimental modification application would serve the public interest, convenience and necessity.

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[1] *See* The Boeing Company, Experimental Radio Station Construction Permit and License, Call Sign WC2XVE, File No. 0002-EX-ML-2004 (granted Jan. 13, 2004).

I. AUTHORINZING EXPERIMENTS WITH THE EXCHANGE AES ANTENNA WOULD FURTHER THE PUBLIC INTEREST

The overall Connexion by Boeing[SM] ("Connexion") AMSS system will operate under the same network control parameters with the eXchange AES antenna as it does with the phased-array and reflector AES antennas that have bee previously authorized by the Commission.[2] As a result, there will be no increased potential for interference (*e.g.*, increase in aggregate off-axis e.i.r.p.) from Boeing's experimental AMSS operations. However, the eXchange AES antenna will have different characteristics (described below), which will be taken into account fully in controlling Connexion network operations.

A. Description of the eXchange AES Antenna and Antenna Experiments

The eXchange AES antenna will transmit and receive using a single circular horn-lens antenna that is mechanically steered to acquire and track the desired satellite through aircraft flight maneuvers and over a large geographic range. The eXchange AES antenna is designed for installation on smaller aircraft, such as narrow body business jets, and will be installed underneath a fairing (radome) on top of the vertical stabilizer at the tail of the aircraft.[3]

The eXchange AES antenna characteristics are summarized in Table 1. A diagram of the antenna is given in Figure 1. Transmit and receive antenna patterns are given in Figures 2 and 3.

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[2] *See id.*; *see also* Radio Station Authorization, Call Sign E000723, File No. SES-MOD-20020308-00429; *The Boeing Company*, Order and Authorization, 16 FCC Rcd. 22645 (Int'l Bur./OET 2001) ("*Transmit-Receive Order*").

[3] The effects on radome loss of various factors such as frequency, pointing angles and polarizations will be determined as part of the tests to be carried out. These factors will be taken into account, to the extent necessary, in designing the link and controlling the AES emissions.

Aperture Dimensions	29.0 cm circular
Antenna Beam-width	4.5º transmit 5.5º receive
Transmit Band	14.0 GHz to 14.4 GHz
Receive Band	11.2 GHz to 12.8 GHz
Transmit Gain	31.9 dBi
Receive Gain	30.3 dBi
Maximum EIRP	40.7 dBW
Maximum ERP	7.2 kW
Minimum G/T	8 dB/K
Minimum Elevation Angle	5º (10º on ground)
Antenna Polarization	Tx: Variable Linear Rx: Dual-Orthogonal Variable Linear

Table 1. eXchange Antenna Characteristics

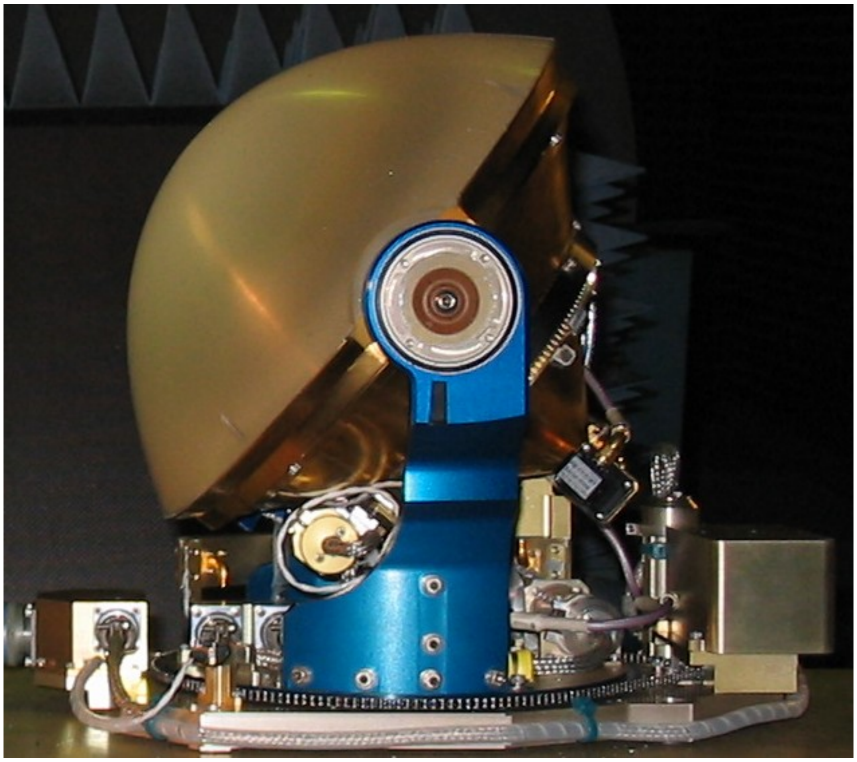

Figure 1. eXchange Antenna

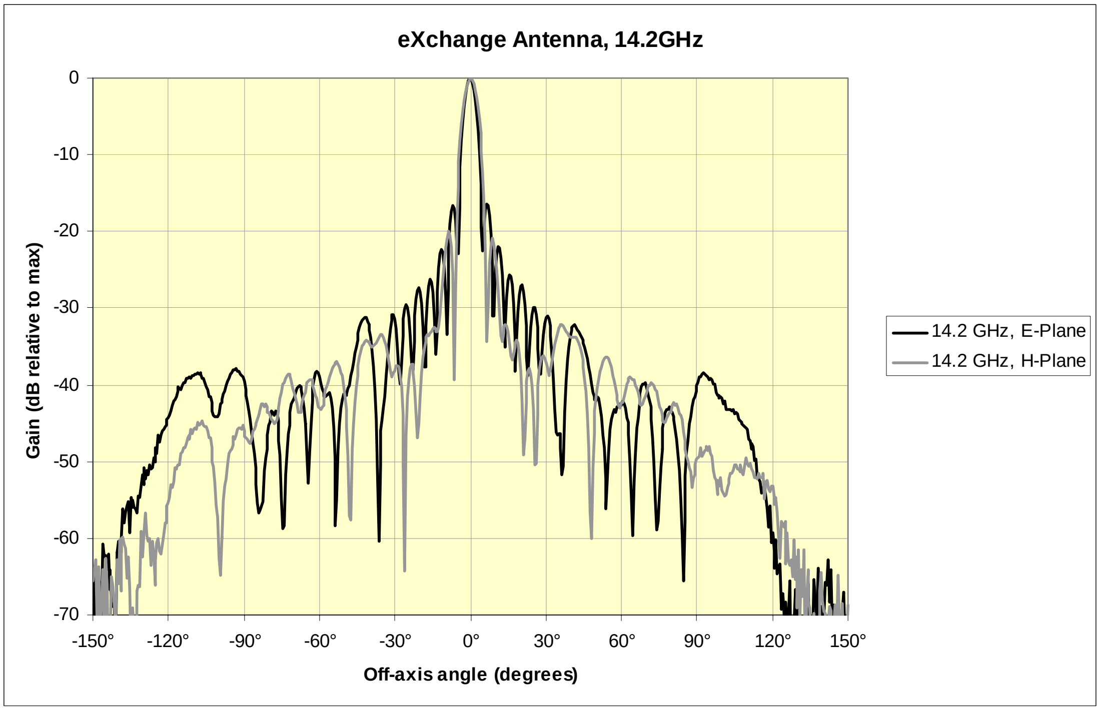

Figure 2. eXchange Antenna Transmit Pattern

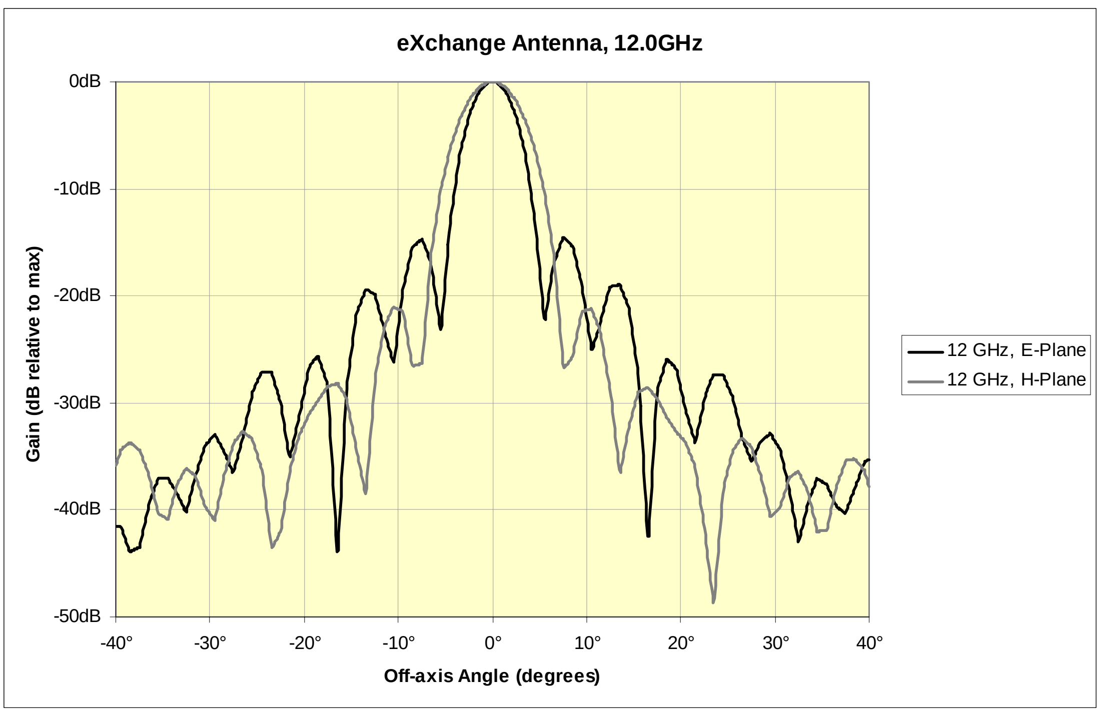

Figure 3. eXchange Antenna Receive Pattern

1. Antenna Pointing Control

The eXchange AES antenna spatial tracking is accomplished by (i) determining the inertial line of sight ("LOS") vector from the airplane to the satellite using airplane and satellite position data; (ii) determining the inertial attitude of the antenna base from airplane IRS (inertial reference system) and antenna PPS (precision pointing system) measurements; and (iii) commanding the antenna gimbals to point the antenna bore sight along the target LOS vector. The eXchange AES antenna is designed to achieve a pointing accuracy of 0.36° 1-sigma. This includes effects-of closed loop tracking error, closed loop servo control error, accuracy of the inertial navigation system ("INS") data, INS data latency, alignment accuracy of the installation, and aircraft body bending between the AES antenna and the location of the INS. The eXchange AES antenna is designed to remain pointed towards the target satellite under normal airplane maneuver rates of <+7 deg/sec in heading, pitch, and roll. If the aircraft exceeds these budgeted maneuver rates, eXchange AES antenna will automatically inhibit transmissions.

The initial acquisition of the satellite forward link is accomplished by means of open loop pointing and polarization control, through the use of the airplane navigation system and antenna rate gyro data; commanded satellite position; and estimated antenna alignment parameters. Following initial acquisition, the eXchange AES antenna pointing is refined using a sequential lobing technique.[4] While the eXchange AES antenna is performing sequential lobing, the transmit e.i.r.p. is restricted so that the off-axis e.i.r.p. limits continue to be satisfied.

[4] This technique is essentially identical to the sequential lobing technique used by Connexion's currently authorized reflector AES antenna. This sequential lobing technique provides a closed loop measure of antenna to satellite pointing performance, the results of which are used to update the antenna alignment parameters. This technique is resistant to being "pulled off" by adjacent satellites.

After acquisition and initial sequential lobing, pointing is accomplished through a combination of open loop pointing and polarization control with periodic closed loop updates. Using this data, the pointing commands to the antenna servos are updated more than 500 times per second. The use of high rate inertial data from the airplane navigation system and antenna rate gyros eliminates the need for the rapid sequential lobing used on the phased array. Periodic closed loop updates to the alignment of the antenna using data from the airplane navigation system are performed approximately every ten to twenty minutes by repeating the sequential lobing described above. This allows the system to account for changes in alignment that result from effects such as aircraft pressurization, fuel load and flight state.

The pointing performance will be verified by testing at the SIF prior to operations on aircraft in flight, and the actual accuracies will be used by Connexion's network operations center ("NOC") when accounting for the variation in off-axis e.i.r.p. caused by any mispointing.

2. Antenna Polarization Control

The polarization tracking of the eXchange AES antenna is accomplished by an open loop computation of the required polarization angle, based on satellite location, transponder polarization, and airplane location and attitude. The polarization control performance of the eXchange AES antenna will be tested and verified during the requested experiments.

3. Power Level Monitoring

a. On-axis e.i.r.p.

The on-axis e.i.r.p. of the eXchange AES antenna is ascertained from direct measurement of the RF power delivered to the antenna to ensure that the transmitter power level is accurately known. The PAU (Power Amplifier Unit) contains a calibrated coupler and a calibrated power detector to measure the power delivered to the output port of the PAU. Together with knowledge of the antenna gain and losses downstream of the PAU (including radome loss), this allows the e.i.r.p. of the eXchange AES antenna to be calculated.

b. Off-axis e.i.r.p.

The aggregate off-axis e.i.r.p. produced by Boeing's experimental operations, including the addition of the proposed eXchange antennas, will be controlled by Connexion's well-proven commercial AMSS network, which has been described fully in Boeing's prior FCC applications. The addition of horn-lens antenna AESs to the Connexion system does not fundamentally affect the algorithm employed by the NOC to control the aggregate off-axis e.i.r.p. of the system to less than or equal to that of a routinely processed VSAT terminals.[5] The off-axis e.i.r.p. produced by a single eXchange antenna will be at least 1.3 dB below the VSAT criteria specified in §§ 25.134(a)(2) and 25.209. Figure 4 plots the off-axis e.i.r.p. of a single AES, using the eXchange antenna pattern shown above, the maximum e.i.r.p. of 40.7 dBW, and a minimum signal bandwidth of 13.5 MHz.

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[5] All AESs operating in the network report their position (latitude, longitude), attitude (heading, pitch, roll), and transmit e.i.r.p. to the NOC. The NOC then uses the reported data, antenna models for each antenna type, and the known tolerances in pointing, antenna pattern, and transmit e.i.r.p. for each antenna type, to compute an aggregate off-axis e.i.r.p. envelope for the AESs operating in the network. This envelope is then compared to the off-axis e.i.r.p. limits for routinely processed VSAT terminals. Based on how closely the envelope approaches the limits, the NOC issues commands to allow additional AESs into the network, change AES data rates/power levels, or remove AESs from the network. Other than adding the specific horn-lens antenna model and tolerances, no changes are needed to this algorithm.

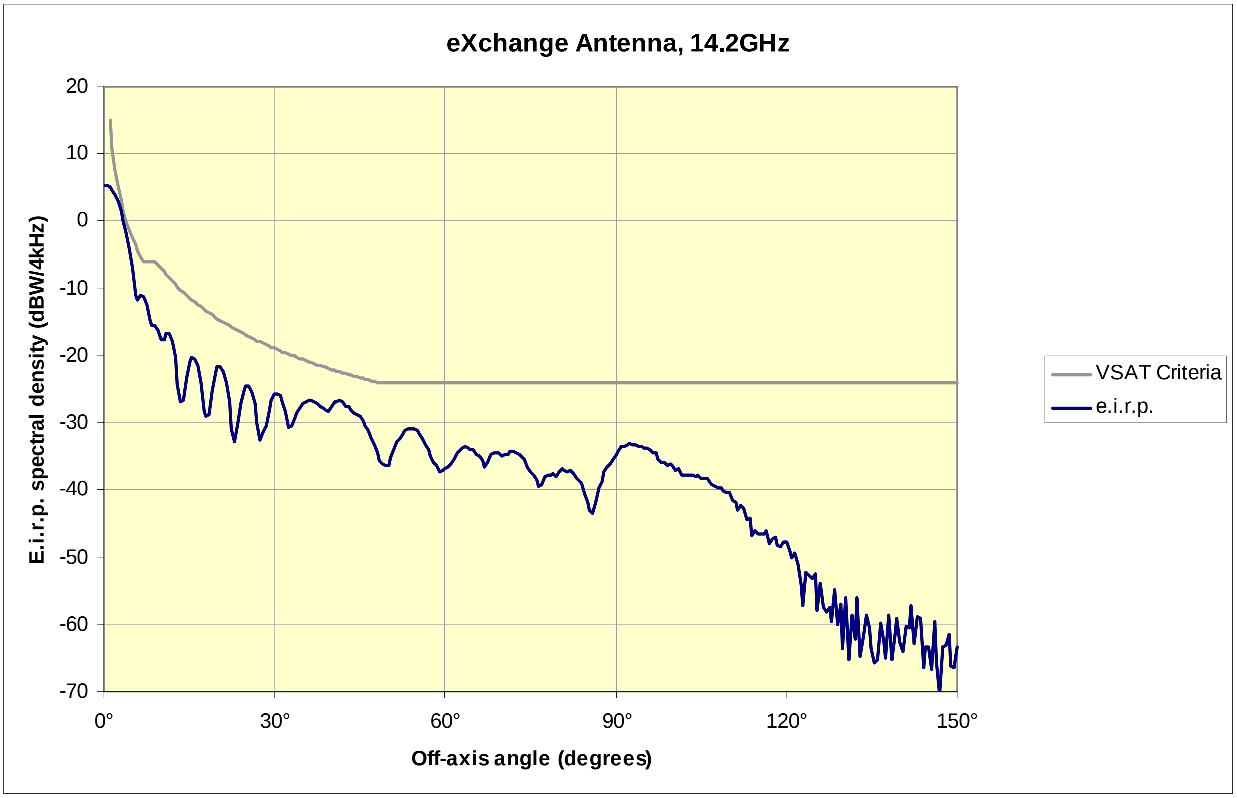

Figure 4. eXchange Antenna Off-axis e.i.r.p. Spectral Density

While the fundamental algorithm employed by the NOC to control the aggregate off-axis e.i.r.p. is unchanged for the eXchange AES antenna, the specific antenna model and tolerances used by the NOC to account for antenna mis-pointing, pattern variation, and e.i.r.p. variation will be included in the algorithm. Boeing will verify each of these parameters through testing and use the measured values in the NOC when accounting for the variation in off-axis e.i.r.p. caused by these factors.

Antenna Mis-Pointing – The eXchange AES antenna is designed to achieve a pointing accuracy of 0.36º 1-sigma in the aircraft dynamic environment. The NOC will account for the actual projection of the eXchange antenna pointing accuracy onto the GSO arc when computing the off-axis e.i.r.p. envelope for the horn-lens antenna.

***Antenna Pattern Variation* –** The eXchange AES antenna model used by the NOC will be substantially simplified because the eXchange AES antenna pattern varies little with antenna pointing angles (elevation and azimuth). The model used by the NOC will be based on the actual performance of the eXchange AES antenna, adjusted to account for unit-to-unit variation and radome effects, and projected along the GSO arc.

***Antenna E.I.R.P. Variation* –** The transmit power is measured after the output of the high power amplifier which, together with knowledge of the antenna gain and losses downstream of the amplifier (including the radome loss), allows the e.i.r.p. of the AES to be calculated. At maximum power, the reported e.i.r.p. uncertainty of the eXchange AES antenna will be only 0.5 dB (1-sigma). The NOC will account for this uncertainty when computing the off-axis e.i.r.p. envelope for the eXchange AES antenna.

B. The eXchange AES Antenna Will Enhance Boeing's Ability To Conduct Experiments To Facilitate the Introduction of AMSS Services

The deployment of the eXchange AES antenna will enhance Boeing's ability conduct experiments facilitating the introduction of advanced two-way broadband AMSS services and thus would serve the public interest. In particular, the eXchange AES antenna is lighter, easier to install and less expensive than the AES antennas used to provide service to large commercial aircraft, and thus will accelerate the implementation and facilitate the provision of the Connexion services to a broader segment of the aviation community.

The same public interest reasons that supported grant of Boeing's previous experimental authorizations are even more compelling in the context of experimental operations using the eXchange AES antenna. For example, the further development of Boeing's AMSS service will help the United States maintain its lead in advanced broadband satellite telecommunications systems and services. In addition, given the Commission's recent renewal of the experimental license of Aeronautical Radio, Inc. ("ARINC") to conduct market tests of Ku-band AMSS services to the general aviation community,[6] grant of this application would promote competition in broadband AMSS services to that important market. Thus, adding authority to operate ten (10) eXchange AES antennas to Boeing's experimental authorization plainly would further the public interest.

Boeing recognizes and accepts that the operational conditions set forth in the Boeing's experimental authorization will apply equally to the operations of its eXchange AES antennas. These conditions already ensure that Boeing's experimental AMSS operations will not cause harmful interference to any authorized station operating in compliance with the Table of Allocations in the 14.0-14.5 GHz band. Furthermore, Boeing confirms that it will continue to meet the stated criteria necessary to protect NASA's TDRSS operations, as well as Radio Astronomy stations observing in the 14 GHz band, as set forth in the applicable agreement and letter referenced in the *Transmit-Receive Order*.[7]

Furthermore, Boeing will continue to operate within the parameters notified with the adjacent satellites as documented in previous filings, so this modification will not adversely affect adjacent satellite operators. Boeing reaffirms that it must not cause harmful interference to any other authorized station operating domestically or internationally in the 14.0-14.5 GHz band, and that it will immediately cease its experimental operations upon notification of any such harmful interference resulting from its experimental operations.

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[6] *See* Aeronautical Radio, Inc., Experimental Radio Station Construction Permit and License, Call Sign WC2XPE, File No. 0130-EX-RR-2004 (granted Nov. 1, 2004).

[7] *See Transmit-Receive Order* at n.20, 21.

II. CONCLUSION

For all of the foregoing reasons, Boeing respectfully requests that the Commission modify its experimental authorization to include authority to operate ten (10) eXchange AES antennas as set forth herein.