Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Application of The Boeing Company	)	Call Sign
for Authority to Operate Up to 100	)	File No.
Earth Stations Aboard Aircraft ("ESAA")	)	

APPLICATION FOR LICENSE

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APPLICATION FOR LICENSE

The Boeing Company ("Boeing") hereby respectfully submits this application for authority to operate 100 earth stations aboard aircraft ("ESAA") in accordance with the Commission's newly-adopted ESAA rules.[1] Boeing seeks to provide in-flight broadband connectivity onboard U.S. aircraft within the United States and abroad using a network of satellites and Boeing's ESAA terminals.

I. INTRODUCTION

Boeing, a world leader in aerospace manufacturing and satellite services, has operated in-flight broadband services for more than a decade. Boeing's Connexion by Boeing ("Connexion") system was the first satellite-based in-flight broadband service authorized by the Commission.[2] Today, the Boeing Broadband SATCOM Network ("BBSN") exclusively serves the needs of the United States Air Force Air Mobility Command to support the operation of critically-important VIP/SAM (Very Important Personnel/Special Air Mission) aircraft used to transport senior

[1] *Revisions to Parts 2 and 25 of the Commission's Rules to Govern the Use of Earth Stations Aboard Aircraft Communicating with Fixed-Satellite Service Geostationary-Orbit Space Stations Operating in the 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz and 14.0-14.5 GHz Frequency Bands, IB Docket No. 12-267*, Notice of Proposed Rulemaking and Report and Order, FCC 12-161 (rel. Dec. 28, 2012) ("*ESAA Order*").

[2] *See The Boeing Company*, Order and Authorization, 16 FCC Rcd. 22645 (Int'l Bur. 2001) ("*Boeing Transmit Receive Order*").

leadership of the U.S. Government and the Department of Defense. Boeing has been operating its BBSN pursuant to a grant of experimental authority from the Commission's Office of Engineering and Technology ("OET") pending the Commission's adoption of its ESAA rules.[3] With these rules in place, Boeing now seeks blanket authority to operate its ESAA terminals pursuant to an ESAA license.

Grant of the requested blanket ESAA authorization will serve the public interest by enabling further implementation of the BBSN in an administratively efficient manner in order to reliably fulfill the growing and evolving requirements of the U.S. Air Force Air Mobility Command with respect to global in-flight broadband capabilities. It will also permit Boeing to provide its BBSN service to other customers as appropriate.

A detailed description of the ESAA terminals is set forth in the attached Technical Appendix.[4] To clearly demonstrate compliance with the Commission's ESAA application requirements, Boeing highlights certain operational characteristics of the BBSN network and the three models of ESAA terminals that Boeing is currently using.

II. THE BOEING BROADBAND SATCOM NETWORK

The BBSN system consists of Boeing terminals installed aboard customer aircraft, worldwide leased satellite capacity on various commercial Ku-band satellites operating in the fixed satellite service ("FSS"), a Network Operations Segment ("NOS"), gateway earth station facilities located in the United States and in other countries containing some of the NOS automated control functionality, and high-speed terrestrial links between network elements.

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[3] *See* Experimental License Call Sign WC2XVE.

[4] *See* Technical Appendix.

A. System Description and Overview

The diagram below shows the five segments of the BBSN: the Space Segment, the Airborne Segment, the Ground Earth Stations Segment, Terrestrial Network Segment and the NOS. The Space Segment consists of leased transponders on a global network of FSS satellites that have been coordinated to support Boeing's operations. The Airborne Segment consists of airborne ESAA terminals with three antenna types described in this Application. The Ground Earth Station Segment consists of authorized commercial and U.S. Government Department of Defense facilities around the world. The Terrestrial Network Segment consist of leased wide area network ("WAN") circuits that interconnect the ground earth stations, network management facilities, customer demarcation points and the Internet. The NOS consists of a continuously manned Network Operations Center ("NOC") located in the United States, servers and the network management system. The NOS performs many critical functions, including controlling the frequency, data rate, and entry of ESAA terminals into the system to protect adjacent satellites from interference. In the BBSN system, the link between the Ground Earth Station Segment and the Airborne Segment is referred to as the "forward link" and the reverse direction between the Airborne Segment and the Ground Earth Station Segment is referred to as the "return link."

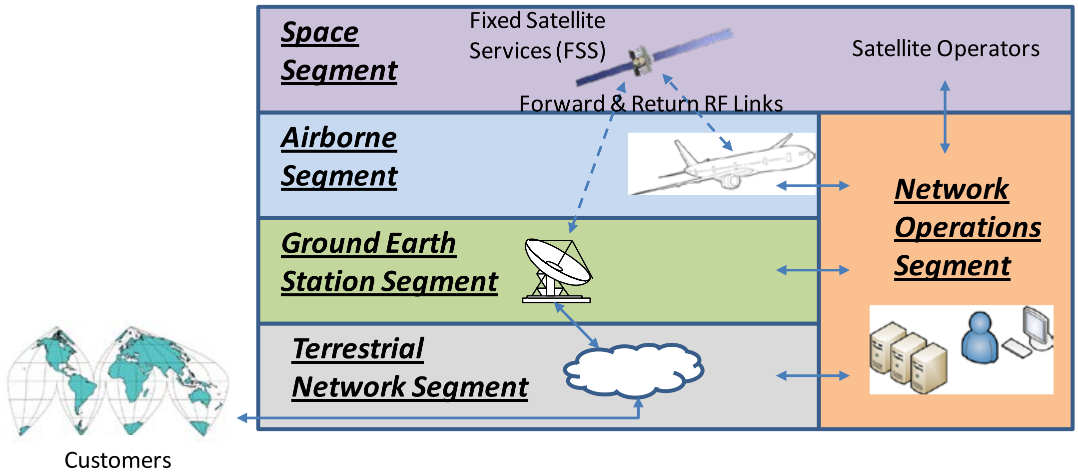

Figure 1. BBSN System Overview

For a typical aircraft, the airborne terminal is powered on when the aircraft cabin power busses receive power. Once data from the aircraft navigation system is available, the receive antenna automatically points to the desired satellite and begins receiving the forward links. The airborne terminal cannot start transmitting to the satellite until it receives authorization from the NOS via the forward link. Upon receipt of authorization, the airborne terminal consults non-transmit policy information stored on the terminal and compares this to aircraft navigation system location information to determine whether the aircraft is permitted to transmit in the return link.

The NOS is the distributed monitoring and management entity for the Boeing service, in particular for the satellite communications links between the ground earth station and the airborne terminals. The NOS ground equipment includes the NOC and Data Center connected via redundant high speed terrestrial links to the ground earth stations. In support of the satellite communications links, the NOS performs the following functions:

- Managing satellite transponder capacity;
- Allocating forward and return link frequencies (transponders), transmit authorization, data rate, and transmit power for each airborne terminal;

- Monitoring of the EIRP levels to each satellite transponder and commanding transmit power changes of selected airborne terminals as required;
- Managing data rate change requests from airborne terminals;
- Managing aggregate off-axis EIRP spectral density ("ESD"), and
- Managing faults of the system, including maintaining system wide keep-alive signaling for positive control of airborne terminal transmissions.

The ground earth station contains transmit and receive equipment for satellite communications with the airborne terminals. This equipment is controlled by the NOS monitoring and management infrastructure. One of the functions provided by the NOS infrastructure is to monitor the Eb/No of the signals received from each airborne terminal and to command airborne terminal transmit power changes as required to maintain Eb/No levels at a predefined set point. The NOS also maintains certain transmission restrictions, which are discussed in subsequent sections.

B. Airborne Terminal Description

Each of the three airborne terminals used by the BBSN comprises the subsystems shown in the schematic diagram in Figure 2, including the Antenna Subsystem ("AS") and the Receive and Transmit Subsystem ("RTS").

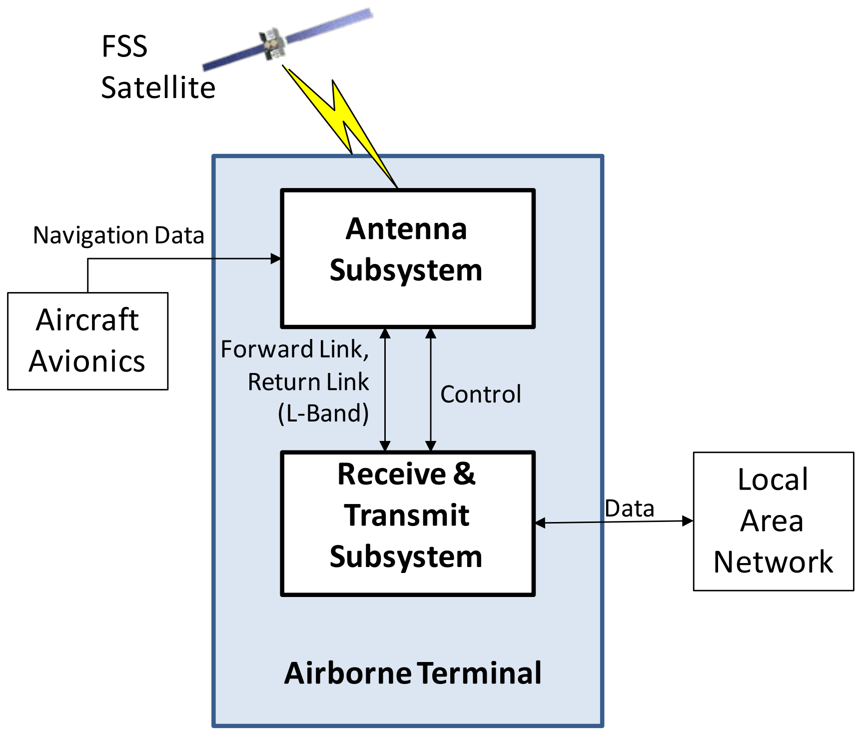

Figure 2. ESAA Terminal Subsystems

The AS provides the Ku-band receive and transmit capability for the airborne terminal and also provides conversion of the Ku-band frequencies and the L-band interfaces to the RTS. The AS shown in Figure 2 comprises the antenna itself, regardless of configuration, as well as the transmit up-converter, receive polarization controller, down-converter, and antenna controller.

The RTS performs demodulation and modulation of the forward and return link signals. For the return (transmit) link, it provides power control as commanded from the ground. It also provides the Receive Signal Strength Indicator ("RSSI") to those AS's that use closed loop spatial tracking. The RTS also controls the operation of the airborne terminal. It is the fault manager for the equipment in order to inhibit transmission in the event of an identified fault that might compromise the NOS positive control of transmissions.

C. Signal Waveforms

The forward and return link waveforms on each of the antenna designs used with the BBSN use direct sequence spread spectrum modulation, a modern low threshold Eb/No Turbo Product Coding Forward Error Correction ("FEC"), and FEC rates down to one third that reduce the waveform's ESD requirement. An added benefit of the waveform used by BBSN is the reduction in the effect of interference to and from other communication systems from and into the Boeing system signals. The waveform modulation specifics are provided in Figure 3. The BBSN modem can support occupied bandwidths up to 32.4 MHz with data rates down to 16 kbps. As explained in Section V.A.1., regardless of the actual occupied bandwidth of the carrier, the BBSN system manages the total aggregate ESD emitted by all active platforms in any specific satellite service region to remain at or below the off-axis ESD limits that are coordinated for the target satellite or specified by Section 25.227(a)(3)(i) of the Commission's rules.

Data Modulation	Direct Sequence Spread Spectrum
Chipping Modulation	Offset-Quadrature Phase Shift Keying ("O-QPSK")
Spreading Bandwidth	Up to 32.4 MHz
Filtering	Square Root Raised Cosine ("SRRC"), Alpha=0.35
Emission Designator Range	420KG7D to 32M4G7D

Figure 3. Summary of Waveform Characteristics

D. Network Control

Transmissions from the aircraft are under positive control of the NOS. This control includes airborne terminal entry into the network, authorization of transmission frequencies, authorizations to change the transmit power/data rate, and enforcement of adherence to off-axis ESD limitations through control of the authorized transmit power level over a constant bandwidth.

1. Entry into the System

The NOS periodically polls all inactive airborne terminals using the forward link. The polling message specifies a return link transponder for which the NOS has reserved sufficient ESD capacity to allow airborne terminal transmissions. When an airborne terminal receives its polling message and a return link is desired, it transmits a response to the NOS over the assigned return link transponder, and the NOS then assigns the airborne terminal "active" status.

Return link power and data rate may be reallocated by the NOS at any time while the airborne terminal is active to meet RF link conditions, comply with off-axis ESD interference limits, and facilitate traffic demands. This management is automatic for normal operation; however, the NOC operators have the capability to control transmission parameters, or to terminate transmissions, in accordance with Sections 25.271(c) and 25.227(a)(5) of the Commission's Rules.

2. Transmit Authorization

An ESAA terminal will transmit only when authorized by the NOS. Transmission starts when the airborne terminal enters the network and continues until it stops for any of the following reasons:

- The ESAA terminal sends a sign-off message to the NOS and stops transmitting;
- The NOS commands the ESAA terminal to stop transmitting;
- The ESAA terminal loses the forward link from the NOS; or
- The ESAA terminal detects an anomalous condition that may indicate loss of positive control of the transmission.

When an ESAA terminal stops transmitting, the NOS will release its transponder capacity for assignment to other ESAA terminals.

The ESAA terminal's assigned data rate/transmit EIRP can be changed under the following conditions:

- The NOS detects a change in the received Eb/No from an airplane and sends a power adjustment command to the airborne terminal;
- The aggregate transponder ESD is approaching its assigned limit, and the NOS commands reduction of data rates and transmit power for selected ESAA terminals; or
- The ESAA terminal requests a change in the data rate and the NOS, after verifying the transponder ESD capacity, will either grant or deny the data rate change request.

3. Fault Management

Fault management ensures that no transmission will occur from any airborne terminal without positive control of that transmission from the NOS. Fault management is designed to ensure that the BBSN network and each of its ESAA terminals function properly and do not exceed the permissible aggregate ESD limits for each satellite. Fault management includes two types of functions – those undertaken under the control of the NOS and those undertaken unilaterally by each airborne terminal. Fault management includes the following functions:

NOS Fault Management

- The NOS monitors all assigned return links. If a return link is lost, the corresponding ESAA terminal is commanded to stop transmitting.
- If the ESAA terminal fails to properly respond to power adjustment commands, the ESAA terminal is commanded by the NOS to stop transmitting.
- If the ESAA terminal fails to properly respond to data rate change commands, the ESAA terminal is commanded by the NOS to stop transmitting.

Airborne Terminal Fault Management

- The airborne terminal will cease transmissions upon detection of any transmit antenna subsystem fault, or transmit control system fault that would adversely impact the transmit signal, such as a loss of antenna pointing control.

- The airborne terminal will cease transmissions after receiving any "parameter change" command that may cause harmful interference to other satellite systems during the change, such as during satellite handover events.

- The airborne terminal will cease transmissions if the antenna subsystem detects a pointing error in excess of 0.5 degrees and will not resume transmissions until the pointing error is within 0.2 degrees.

- The airborne terminal will cease transmissions upon detection of a loss of communication between the airborne RTS and the antenna subsystem.

- The airborne terminal will cease transmissions if the airborne RTS detects a loss of the forward (receive) link from the satellite or positive control from the NOS.

With respect to the final bullet above, the BBSN operates using a keep-alive signal that is continuously exchanged between the NOS and all active ESAA terminals. If this signal is not received as expected, the ESAA terminal will stop transmitting.

III. THE BOEING ESAA TERMINALS

The BBSN employs three different ESAA terminals depending on the aircraft and mission requirements. Boeing has previously sought and received authority to operate two of them, the Boeing Phased Array terminal ("Boeing Phased Array Terminal") and the Mitsubishi Reflector Antenna ("MELCO Reflector Terminal").[5] An additional ESAA terminal, the TECOM KuStream 1500 ("KuStream 1500") was added as an additional terminal on Boeing's experimental license authorization.[6] Boeing provides a detailed technical description of each of

[5] *See Boeing Transmit Receive Order* (authorizing Boeing's use of the Boeing Phased Array Terminal)*, Satellite Communications Services Information Re: Actions Taken,* Public Notice, Report No. SES-00553 (Int'l Bur., rel. Nov. 19, 2003) (public notice of grant of modification of Boeing's license to allow use of MELCO Reflector Terminal).

[6] Letter from Ronald E. Center, Manager, U.S. Spectrum Management, The Boeing Company, to Federal Communications Commission, Experimental Licensing Branch, Call Sign WC2XVE, File No. 0491-EX-ST-2012 (Jan. 21, 2013) ("*New AES Notification Letter*").

the three terminals (collectively the "ESAA terminals") in the attached Technical Appendix, and briefly summarizes the background and function of each antenna below.

A. Boeing Phased Array Antenna

The Boeing Phased Array terminal transmits and receives signals using a pair of flat panel antennas that are electronically steered to acquire and track the desired satellite over a large geographic range and through the most severe aircraft flight maneuvers expected of a commercial or government-owned aircraft.

On December 21, 2001, the Commission granted Boeing authority to operate up to 800 technically identical transmit/receive phased-array terminals 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.[7] Boeing provides the required technical information on the Boeing Phased Array in the attached Technical Appendix.[8]

B. MELCO Reflector Terminal

The MELCO Reflector Terminal was developed by Mitsubishi Electronics Company for the Connexion by Boeing AMSS system. It is a mechanically-steered Cassegrain antenna with an elliptical profile designed to be compatible with installation and operation onboard an aircraft. On November 14, 2003, the Commission granted Boeing's application to modify its AMSS license to include the MELCO Reflector Terminal.[9] Boeing now seeks authorization for use of

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[7] *See* The Boeing Company, FCC File No. File No. SES-LIC-20001204-02300, Radio Station License Call Sign E000723; *See also Transmit-Receive Order,* ¶¶ 19-22.

[8] *See* Technical Appendix at 1.

[9] *Satellite Communications Services Information Re: Actions Taken,* Public Notice, Report No. SES-00553 (Int'l Bur., rel. Nov. 19, 2003) (public notice of grant of modification of Boeing's license to allow use of MELCO Reflector Terminal).

this terminal under the ESAA rules. Boeing provides the required technical information on the MELCO Reflector Terminal in the attached Technical Appendix.[10]

C. TECOM KuStream 1500

The KuStream 1500 terminal, manufactured by TECOM/Qest, is a high power version of the KuStream 1000 terminal that has been previously authorized by the Commission for both experimental and commercial AMSS operations.[11]

On January 21, 2013, Boeing notified the Commission that it intended to operate the KuStream 1500 antenna as part of Boeing's existing experimental license.[12] Boeing now seeks authorization for use of this terminal under the ESAA rules. Boeing provides the required technical information on the KuStream 1500 in the attached Technical Appendix.[13]

IV. SATELLITES AND AREA OF OPERATION

Through the use of leased transponder capacity on satellites worldwide, BBSN is able to offer near global connectivity. With this Application, Boeing seeks authority for its operations with U.S.-flagged aircraft in the United States and its territorial waters. Boeing also seeks authority for its operations with U.S.-flagged aircraft outside the United States, such as over international waters. With respect to Boeing's operation of its ESAA network with aircraft in the airspace and territories of foreign jurisdictions, Boeing has secured all requisite authority from

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[10] *See* Technical Appendix at 5.

[11] For example, the TECOM terminal was authorized for aeronautical experimental operations by Row 44, Inc. in 2009 (File No. 0236-EX-PL-2009, Call Sign WF2XBY), and for commercial operations in 2010 (File No. SES-MOD-20091021-01342, Call Sign E080100). (*See also* Intelsat, file no. 0196-EX-ST-2012, call sign WF9XNE).

[12] *New AES Notification Letter*.

[13] *See* Technical Appendix at 8.

the relevant foreign administrations and Boeing operates its network in compliance with the laws, regulations, and rules of those countries.[14] In those countries where no relevant rules exist, Boeing operates pursuant to the terms of the Commission's rules.

Boeing requests authority to operate its ESAA terminals with the satellite points of communications identified in Table 1, below. Except for the E113WA satellite, which Boeing seeks to add as a point of communication with this Application, all of the listed satellites are currently being used to support BBSN operations onboard government VIP aircraft and they are integral elements of the BBSN system.

Boeing seeks authority to operate using the frequency bands that are utilized by its target satellites in those regions of the world served by those satellites. With respect to operations using the 11.7-12.2 GHz and the 14.0-14.5 GHz bands, Boeing seeks primary authority to operate in this spectrum under the Commission's ESAA rules.

With respect to operations using the 11.45-11.7 GHz band in the space-to-Earth direction, Boeing seeks authority for the reception of FSS emissions from the identified geostationary ("GSO") satellites subject to the condition that Boeing's ESAA terminals shall not claim protection from transmissions of non-Federal stations in the fixed service.[15] Boeing's operations using the 11.45-11.7 GHz band will occur almost entirely outside the United States, although Boeing seeks authority to use receive space-to-Earth transmissions using these frequencies in the North Atlantic, Pacific Coast and Hawaiian regions of the United States to the extent that the identified satellites are authorized to serve this area.

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[14] *See ESAA Order*, ¶ 122.

[15] *See id.,* ¶ 21.

With respect to operations using the 12.2-12.75 GHz bands in the space-to-Earth direction, Boeing seeks authority to use these spectrum bands on a non-conforming, non-interference basis. These non-conforming operations will occur entirely outside the United States, except for operations in Guam.

Satellite	Orbital Location	Earth-to-Space Frequencies	Space-to-Earth Frequencies	Coverage Area	Service in U.S.
AMC-15	105° W.	14.0-14.5 GHz	11.7-12.2 GHz	North America	Yes
E36B (formerly Eutelsat W7)	36° E.	14.0-14.5 GHz	11.45-11.7 GHz	Europe	No
Eutelsat 7A	7° E.	14.0-14.5 GHz	12.2-12.75 GHz	Africa	No
Eutelsat 172A (Northern beam)	172° E.	14.0-14.5 GHz	11.45-11.7 GHz	North Pacific	Yes
Eutelsat 172A (Southern beams)	172° E.	14.0-14.5 GHz	11.45-11.7 GHz, 12.2-12.75 GHz	Southwest Pacific Guam	Guam
Intelsat 907	27.5° W.	14.0-14.5 GHz	11.45-11.7 GHz	Eastern North Atlantic	No
SES-1	101° W.	14.0-14.5 GHz	11.7-12.2 GHz	North America	Yes
Superbird C2	144° E.	14.0-14.5 GHz	12.2-12.75 GHz	Indian Ocean & India	No
Telesat-11N	37.5° W.	14.0-14.5 GHz	11.45-11.7 GHz	North Atlantic	Yes
E113WA (formerly SatMex 6)	113 W.	14.0-14.5 GHz	11.7-12.2 GHz	North, Central & South America	Yes

Table 1. Satellite Points of Communication

The hub earth stations associated with these satellites are as follows:

Satellite	Hub Earth Station Location
AMC-15	Littleton, CO, US
E36B	Croughton, UK[16]
Eutelsat 7A	Rambouillet, France

[16] The earth station facility in Croughton, UK is a U.S. Government DOD facility.

Eutelsat 172A	Napa, CA US; Perth, Australia
Intelsat 907	Croughton, UK[17]
SES-1	Littleton, CO, US
Superbird C2	Perth, Australia
Telesat-11N	Littleton, CO, US
E113WA	Stamford, CT, US

Table 2. Satellite Points of Communication

Including these satellites as authorized points of communication would serve the public interest by enabling Boeing to serve aircraft on virtually all international routes, thereby allowing its U.S. government customers to exploit the full benefits of the BBSN system's global coverage.

V. PROTECTION OF OTHER SPECTRUM USERS

In the ESAA Order*,* the Commission adopted requirements addressing interference considerations for ESAA licensees, which are primarily set forth in 47 C.F.R. § 25.227. As explained below, Boeing fully complies with the Commission's requirements for protection of FSS networks, terrestrial operations, the Tracking and Data Relay Satellite System ("TDRSS"), and the Radio Astronomy Service ("RAS"). Boeing can also comply with the Commission's requirements for protection of potential future non-geostationary ("NGSO") operators.

A. Protection of Geostationary Satellites

Control of off-axis ESD is essential to protect adjacent FSS satellites operating in the Ku-band. The ESAA Order adopted an "envelope" of off-axis ESD limits that restrict the off-axis ESD of all transmitting earth stations, whether singly or as part of a system, to the same levels generated by an ordinary FSS fixed earth station communicating with a GSO FSS space station.[17] The Commission's rules further require that ESAA networks that use variable power-density control of individual simultaneously transmitting co-frequency ESAA terminals must operate either 1 dB below the ESD limits defined in the Commission's rules, or secure certificates from target satellite operator indicating that such higher power levels have been coordinated with adjacent satellite operators within 6 degrees in each direction.

The Boeing ESAA network uses variable power-density control of individual simultaneously transmitting co-frequency ESAA earth stations in the same satellite receiving beam. Therefore, pursuant to Sections 25.227(a)(3)(ii) and 25.227(b)(3)(ii), Boeing is providing with this Application statements from the operators of most of its target satellites certifying to the information required by the Commission's rules, including the fact that the aggregate ESD limits that the Boeing ESAA system adheres to are consistent with the coordination agreements between the target satellite operator and the operators of adjacent satellite systems within 6 degrees of orbital separation. These coordinated levels are higher than 1 dB below the off-axis ESD limits defined in Section 25.227(a)(1)(i)(A)-(C) of the Commission's rules. Boeing herein certifies that all of its target space station operators that have provided letters for this Application have confirmed that Boeing's ESAA operations are within the coordination parameters for the subject satellite and with adjacent satellites up to six degrees away.[18]

With respect to two of its target satellites, AMC-15 and SES-1, Boeing has not yet secured a letter from the operator of the satellites providing certifications in the manner required by the Commission's ESAA rules. Boeing therefore herein certifies that, until such time as this letter is supplied to the Commission, Boeing's operations pursuant to the ESAA rules will

[17] *ESAA Order*, ¶¶ 44, 46; 47 C.F.R. § 25.227(a)(1)(i)(A).

[18] *See id.*, ¶ 124.

comply with the 1 dB power reduction specified by Section 25.227(a)(3)(i) with respect to these two satellites.

1. Control of Aggregate EIRP Spectral Density

Based on its considerable experience operating its ESAA network, Boeing is confident that it has in place sufficient measures to maintain the effective aggregate ESD from all simultaneously transmitting co-frequency terminals operating with the same satellite transponder at or below the ESD limits indicated in the Commission's rules or supplied by the target satellite operator. The antenna control algorithms used by the Boeing NOS account for variations in aggregate off-axis ESD caused by variations in antenna transmit EIRP and variations in antenna transmit gain patterns as projected onto the GSO arc. As described below, each element of the control algorithm is designed to compensate for off-axis ESD variation and ensure that the aggregate off-axis ESD of Boeing's system remains within the appropriate levels. Boeing has been operating its antenna control and ESD monitoring algorithms for more than ten years without experiencing a single adverse satellite interference event.

The Boeing ESAA control algorithm uses the reported state of all ESAA terminals that have been authorized by the NOS to operate in the network to calculate the aggregate off-axis ESD and control the individual ESAA transmissions in compliance with the application ESD levels, as shown in Figure 4. All ESAA terminals operating in the network regularly report to the NOS their position (latitude, longitude), transmit EIRP, and also report attitude (heading, pitch, and roll) as required. The NOS then uses the reported data to compute an aggregate off-axis ESD envelope for the terminals operating in the network. For terminals that do not report their attitude, the NOS will take into account a worst case antenna pattern for the terminal at the reported aircraft location. This envelope is then compared to the off-axis ESD limits applicable to the target satellite. Based on how closely the envelope approaches the limits, the NOS issues commands to allow additional ESAA terminals into the network, allow changes in individual terminal data rates/power levels, or remove terminals from the network.

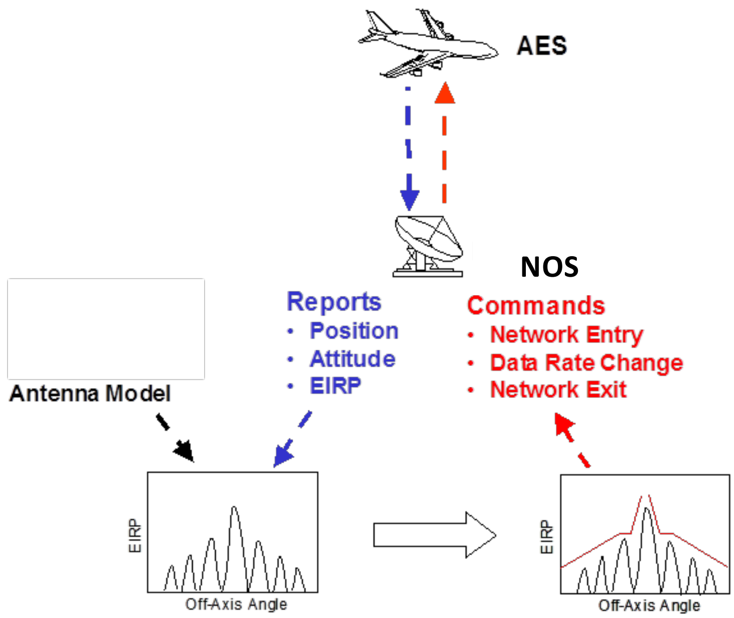

Figure 4. Control of Off-axis ESD

Each individual ESAA terminal reports position, attitude and transmit EIRP data at least once every 30 seconds or when its transmit EIRP has changed sufficiently to cause its off-axis ESD to change by more than 0.2 dB. All ESAA terminal EIRP changes are calculated by the NOS before being sent to the ESAA terminal.

Using the reported EIRP, the ESD manager software in the NOS calculates the antenna pattern ESD gain envelope for each operational platform as projected along the GSO arc using the antenna model applicable for the reporting terminal. All antennas operational in the system have antenna models associated with them in the ESD manager that will estimate or overestimate (estimate higher ESD gain pattern than the antenna can actually produce) actual antenna performance. The ESD manager will account for all required variables that may impact antenna performance as needed, such as antenna azimuth, antenna elevation and antenna transmit polarization. Once the ESD pattern for all platforms operating on a specific satellite have been calculated, the patterns are summed and compared to the applicable off-axis ESD limit. The NOS recalculates the aggregate EIRP envelope whenever an ESAA terminal makes a report and prior to admitting any additional terminals on to the network or permitting a terminal to increase its data rate.

2. Monitoring and Automatic Shutdown

The BBSN network and each of the ESAA terminals operating on the BBSN comply with those Commission rules related to monitoring and shutdown requirements.[19] Each ESAA terminal is continuously monitored by the NOS to determine if it is functioning correctly. The NOS is capable of shutting off an individual transmitter or the entire system in the event of a detected fault, or if the aggregate off-axis ESD begins to approach, or exceeds, the applicable limit for the target satellite.

In addition, each ESAA terminal self-monitors its functions and automatically ceases transmissions within 100 milliseconds after sensing an operation fault that can cause harmful interference to an adjacent FSS satellite. The Boeing system uses heart beat timers to detect proper operations of all major satellite communications system components installed on the ESAA terminal and will automatically cease operations within 100 milliseconds after detecting any of the following conditions or faults identified above in Section II.D.3. of this Application. As a result of these measures, Boeing herein certifies as required by § 25.227(b)(7) of the

[19] *See*, *e.g.*, § 25.227(a)(2)(iii), § 25.227(a)(3)(i), § 25.227(a)(3)(ii) (B), § 25.227(a)(9), § 25.227(a)(10), § 25.227(a)(11), § 25.227(b)(1)(iv)(B) (various Commission rules pertaining to transmission cessation requirements).

Commission's rules that the BBSN system complies with the terminal self-monitoring and cessation requirements of § 25.227(a)(9)-(11) of the Commission's rules.

3. Antenna Pointing

The pointing methodology employed by each ESAA terminal type is unique to that terminal type and is described in the Technical Appendix. The BBSN terminals employ a tracking algorithm that is resistant to capture by adjacent satellite signals and is capable of inhibiting its own transmission in the event it detects unintended satellite tracking and tracking errors in excess of 0.5 degrees. For the mechanically tracking antennas – the KuStream 1500 antenna and the Boeing Reflector Antenna – the antennas will mute transmit within 100 milliseconds after detecting a pointing error between the antenna pointing vector and the antennas commanded pointing vector that exceeds 0.5 degrees, and transmission will not resume until such angle is less than or equal to 0.2 degrees. The Boeing Phased Array Antenna employs electronic antenna beam steering enabling the antenna to update its pointing vector within milliseconds ensuring that the antenna is always pointing towards the commanded pointing vector.

4. Contention Protocol

Boeing is considering the possible future use of a contention protocol-based process in which predictive measures are used to permit ESAA terminals to enter and leave the network. Boeing herein certifies that, to the extent that such a contention protocol-based approach is employed, Boeing shall ensure that such use will be reasonable in order to prevent harmful interference to authorized spectrum users.

B. Protection of Non-Geostationary Systems

Control of off-axis ESD is also required to protect potential future NGSO satellites operating in the Ku-band. The ESAA Order adopted an "envelope" of off-axis ESD limits that restrict the off-axis ESD of all transmitting earth stations, whether singly or as part of a system, in directions other than along the GSO arc.[20] Given the absence of NGSO networks operating in the Ku-band at this time, Boeing seeks a waiver of this requirement in Section VII.B, below.

C. Protection of Terrestrial Systems

When operating within line-of-sight of the territory of a foreign administration where fixed service networks have a primary allocation in the band being used, the BBSN ESAA terminals will limit power spectral density ("PSD") to below the values coordinated with the foreign administration or those established in Section 25.227(a)(13)[21] if no coordination exists. Likewise, the BBSN ESAA terminals will not transmit while on the ground when the nominal angle of transmission is less than 5 degrees as measured from the plane of the horizon to the direction of maximum radiation.[22]

D. Protection of Space Research Services

ESAA licensees proposing to operate in the 14.0-14.2 GHz sub-band within radio line-of-sight of the National Aeronautics and Space Administration ("NASA") Tracking and Data Relay Satellite System ("TDRSS") receive facilities at Guam, White Sands, New Mexico, and Blossom Point, Maryland are required to reach coordination agreements to protect these facilities

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[20] *ESAA Order*, ¶¶ 55, 56; 47 C.F.R. § 25.227(a)(1)(i)(A).

[21] *Id.*, ¶ 97; 47 C.F.R § 25.227(a)(13).

[22] *Id.*, ¶ 100.

before beginning operations.[23] Boeing has entered into a coordination agreement with NASA regarding the protection of current and future TDRSS sites. Boeing is currently working with NASA to update this agreement to reflect the addition of the Blossom Point facility. Until this new agreement is finalized, Boeing will not operate using the 14.0-14.2 GHz band within line-of-sight of Blossom Point.[24]

E. Protection of Radio Astronomy Services

ESAA licensees proposing to operate in the 14.47-14.5 GHz sub-band within line-of-sight of Radio Astronomy Service ("RAS") facilities must coordinate with the National Science Foundation ("NSF") before beginning operations.[25] Boeing has entered into a coordination agreement with the NSF specifically limiting the PFD levels of Boeing's ESAA network.

VI. COMPLIANCE WITH OTHER ESAA REQUIREMENTS

The BBSN system fully complies with the Commission's rules governing the operation and management of ESAA systems, as explained below.

A. Network Monitoring and Logging

At least once per minute, the BBSN ESAA terminals record operational latitude, longitude, altitude, transmit frequency, channel bandwidth and satellite. The recorded data is periodically transferred to the ground network for storage. The data is stored for at least

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[23] *Id.*, ¶ 27; 47 C.F.R. § 25.227(c)(1).

[24] Outside the United States, where necessary, Boeing will avoid or cease AES emissions on frequencies used by the SRS systems when operating in the vicinity of SRS sites in accordance with local regulations.

[25] *ESAA Order*, ¶ 30; 47 C.F.R. § 25.227(d)(1).

12 months and can be provided in electronic file format within 24 hours upon request from appropriate authorities.

Boeing maintains a 24-hour-a-day NOC in Kent, Washington. The contact information for the Boeing NOC is:

John Faretra
(253) 773-0609
BBSN NOC
BBSNNOC@Boeing.com
20403 68th Ave South
Kent, WA 98032
BLDG 18-61.1
MC 8R91

B. Aircraft Ground Operations and Radio Frequency Hazard Analysis

Boeing seeks authority herein to operate its ESAA terminals intermittently while on the ground for maintenance, commissioning and other purposes. As required by the Commission's rules, Boeing's ESAA terminals maintain a 5 degree minimum elevation angle when operated on the ground.[26] Boeing also employs reasonable and customary measures to prevent human exposure to harmful non-ionizing radiation exceeding the maximum permissible exposure limits specified in Section 1.1310 of the Commission's rules. Boeing has provided radiation hazard safety instructions to its customer that are specific to each antenna design. The instructions include an advisory to the customer to refrain from operating the ESAA terminals while aircraft are on the ground and being serviced from overhead, such as for de-icing. A radiation hazard analyses for each of the ESAA terminals are provided as an attachment to the Technical Appendix.

[26] *See id.*, ¶ 100.

C. Additional Certifications

To the extent not already certified in other sections of this Application, Boeing herein certifies that it shall comply with subsections (a)(6), (a)(9), (a)(10), (a)(11) of Section 25.227 of the Commission's rules.

D. Communications Assistance for Law Enforcement

The Communications Assistance for Law Enforcement ("CALEA") Act requires telecommunications carriers to ensure that their equipment and services are capable of meeting four general "assistance capability requirements."[27] The Commission has not imposed specific rules on ESAA operators with regard to implementing CALEA obligations, instead noting that public safety, law enforcement, and national security concerns have been "traditionally addressed…through individual negotiations with law enforcement agencies."[28] Consistent with this well-advised approach, Boeing worked extensively with law enforcement agencies to address CALEA obligations and public safety concerns. This said, Boeing's ESAA network currently serves only federal government aircraft and therefore the CALEA measures that Boeing implemented for its commercial service are arguably not applicable to its government-only service.

E. Permit-But-Disclose Status

Boeing requests the Commission to designate this Application proceeding as permit-but-disclose for purposes of the *ex parte* rules. Section 1.1200(a) of the Commission's rules allows

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[27] Pub. L. No. 103-414, 108 Stat. 4279 (1994) (codified as amended in sections of 18 U.S.C. and 47 U.S.C.); Communications Assistance for Law Enforcement Act and Broadband Access and Services, ET Docket No. 04-295, Notice of Proposed Rulemaking and Declaratory Ruling, 19 FCC Rcd 15676 (2004) ("*CALEA Notice*").

[28] *ESAA Order*, ¶ 138.

the Commission to modify the *ex parte* status of a proceeding if such modification is in the public interest. Although the issues raised in this Application are straightforward, grant of permit but-disclose status for the application proceeding will facilitate communication between the Commission, Boeing and any interested parties. This, in turn, will allow the Commission to develop a full and complete record, and process the aapplication as efficiently and expeditiously as possible. Accordingly, permit-but-disclose status will serve the public interest.

VII. WAIVER REQUESTS

The Commission's Rules may be waived "for good cause shown."[29] In particular, a waiver of the U.S. Table of Allocations to permit non-conforming spectrum uses can be granted "when there is little potential interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services."[30] A waiver is also appropriate where a grant "would not undermine the underlying policy objectives of the rule in question" and would be in the public interest.[31] As explained below, each of these standards is satisfied in this case. Boeing's BBSN system has operated worldwide for years under an experimental license without causing interference. The proposed waivers conform to the Commission's underlying policy considerations and promote efficient spectrum use as well as maximizing the effectiveness of Boeing's ESAA services.

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[29] 47 C.F.R. § 1.3; *WAIT Radio v. FCC*, 418 F.2d 1153, 1157 (D.C. Cir. 1969).

[30] *See Boeing Transmit Receive Order*, ¶ 12; *Fugro-Chance, Inc.*, Order and Authorization, 10 FCC Rcd. 2860, 2860, ¶ 2 (Int'l Bur. 1995) (authorizing non-conforming MSS in the C-band); *see also Motorola Satellite Communications, Inc.*, Order and Authorization 11 FCC Rcd. 13952, 13956, ¶ 11 (Int'l Bur. 1996) (authorizing service to fixed terminals in bands allocated to the mobile-satellite service).

[31] *See GE American Communications, Inc.*, Order and Authorization, 15 FCC Rcd. 3385, 3391, ¶ 14 (Int'l Bur. 1999).

A. Use of Additional Frequency Bands in Other Regions

Boeing seeks a waiver of the Table of Frequency Allocations to permit use of additional frequency bands in other regions of the world, such as the 12.2-12.75 GHz and the 11.45-11.7 GHz band for space-to-Earth operations. In many countries, Ku-band FSS downlinks are allocated in spectrum other than the 11.7-12.2 GHz band. For example, the band 12.2-12.5 GHz is allocated by the international Radio Regulations to the FSS in Region 3 and the band 12.5-12.75 GHz is allocated to the FSS in Regions 1 and 3. Thus, global ESAA systems require access to the appropriate frequencies when in these regions in order to provide seamless service around the world. Further, the Commission has permitted some of these satellites to provide services into the United States. As the Commission explained in the ESAA Order, although the ESAA proceeding did not seek comment on such authorization, "in the event an interest in providing ESAA develops and matures in this band, licensing of such services can be addressed on a case-by-case basis."[32] Authorization is warranted in this case because the global reach of ESAA services necessarily requires access to foreign satellites, and such operations will have no adverse effects on U.S. operations.

B. Protection of Non-Geostationary Systems

Control of off-axis ESD levels is also required to protect potential future NGSO satellites operating in the Ku-band. The ESAA Order adopted an "envelope" of off-axis ESD limits that restrict the off-axis ESD of all transmitting earth stations, whether singly or as part of a system, in directions other than along the GSO arc.[33] Given the current absence of any NGSO networks operating in the Ku-band, Boeing seeks a waiver of this requirement. Such a waiver would

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[32] *ESAA Order*, ¶ 140.

[33] *Id.*, ¶¶ 55, 56; 47 C.F.R. § 25.227(a)(1)(i)(A).

permit Boeing to operate its network in the most spectrally efficient manner until such time as a Ku-band NGSO network is launched and is operating. The Commission has granted similar waivers to other operators of ESAA and AMSS networks. Boeing acknowledges that, although there has been recent speculation regarding the possible future development of a Ku-band NGSO network by a commercial entity in the United States, no firm plans for such a network have been announced.

VIII. PUBLIC INTEREST SHOWING

Boeing's BBSN network exclusively serves the needs of the United States Air Force Air Mobility Command in support of critically-important air transport operations. BBSN is used by the Air Force to enable broadband capabilities on more than a dozen Very Important Personnel/Special Air Mission aircraft operated by the U.S. Air Force to transport senior leadership of the U.S. Government and the Department of Defense.

The geographic reach and operational capabilities sought by the U.S. Air Force have continued to increase since Boeing first began providing its service to the federal government more than ten years ago. In 2012, the Air Force expressed a significant need for Boeing to expand the reach of the BBSN to include Sub-Saharan Africa, a central focus of Homeland Security efforts. In response, Boeing secured Commission approval to add the Eutelsat 7A satellite as an additional point of communication for the BBSN network. Presently, the Air Force is seeking expanded BBSN capabilities in Latin America to support increased air transport requirements in that region. Boeing is requesting in this application the addition of the E113WA (formerly SatMex 6) satellite to address that additional requirement.

Grant of the requested authorization and waivers will ensure that Boeing's support of critical U.S. Air Force communications services is carried out consistent with the Commission's newly-adopted ESAA rules and consistent with the operational requirements of the U.S. Air Force, promoting administrative efficiency for all entities involved and adding to the record of successful operation of ESAA. As explained in Boeing's waiver requests, grant of the requested waivers will not increase the risk of harmful interference to any spectrum users. The requested waivers are carefully designed to maximize the efficiency and effectiveness of the BBSN system in the context of existing and spectrum uses. Boeing therefore requests that the Commission expeditiously grant this Application.

ATTACHMENT 1

Engineer's Certificate

Technical Certificate

I, Paulus J. Martens, hereby certify that I am the technically qualified person responsible for the preparation of the technical discussion contained in this Application and associated Technical Appendix, that I am familiar with Part 25 of the Commission's Rules (47 C.F.R. Part 25), and that I have either prepared or reviewed the technical information submitted in this application and found it to be complete and accurate to the best of my knowledge and belief.

By: __________________________

Paulus J. Martens
Associate Technical Fellow
Systems Engineering
The Boeing Company
September 16, 2014

ATTACHMENT 2

Satellite Operator Coordination Letters

eutelsat
communications via satellite

September 17, 2014

Ms. Carol Peterson
Supplier Management
The Boeing Company
P.O. Box 3707
Seattle, WA 98124-2207

Re: Eutelsat Power Level Density Certification for Boeing Earth Station Aboard Aircraft (ESAA) transmissions.

Dear Ms. Peterson,

Eutelsat confirms and hereby certifies the following with respect to the operations proposed in the above reference application:

(a) The proposed Ku-band Earth Station Aboard Aircraft (ESAA) operation of The Boeing Company has the potential to create harmful interference to satellite networks adjacent to the target satellite(s) that may be unacceptable;

(b) The Boeing Company is currently using Eutelsat capacity on the following satellites: Eutelsat 7A at 7°East ("E7A"), Eutelsat 36B at 36°East ("E36B"), Eutelsat 113WA at 113°West ("E113WA"), and Eutelsat 172A at 172°East ("E172A"). These operations are subject of the following conditions:

The off-axis EIRP in any 40 kHz band in the direction of an adjacent satellite shall not exceed the following values:

[REDACTED]

Where θ is the angle, in degrees, between the main-beam axis and the direction considered,

Eutelsat S.A. · société anonyme à Conseil d'Administration au capital de 987 459 990 € · RCS n° 422 551 176 Paris
Siège social · 70 rue Balard · F-75502 Paris Cedex 15 · France · tel. +33 1 53 98 47 47 · fax +33 1 53 98 37 00

And where Y is defined, according the satellite - transponder as follow:

Capacity	Frequency band (MHz)	Polarisation	Y

[REDACTED]

The existing services operated by Boeing on the mentioned satellites, when operated in the prescribed manner, do not result in unacceptable interference to the adjacent satellite networks.

The above power density levels are consistent with the Eutelsat's coordination agreements for the satellite here above mentioned.

Eutelsat confirms that, if operated as described here above, operation of the Boeing ESAA terminal will not cause unacceptable interference into operations of the satellites adjacent to E7A, E36B, E113WA and E172A.

Please let us know if you require any further support from Eutelsat relative to Boeing's operations on the Eutelsat satellites.

Sincerely,

for Eutelsat
Jacques Dutronc
Chief Development and Innovation Officer

Eutelsat S.A. · société anonyme à Conseil d'Administration au capital de 658 555 372.80€. RCS n° 422 551 176 Paris
Siège social · 70 rue Balard · F-75502 Paris Cedex 15 · France · tél. +33 1 53 98 47 47 · fax +33 1 53 98 37 00

INTELSAT
Envision. Connect. Transform.

11th August 2014

The Boeing Company
P.O. Box 3707
Seattle, WA 98124-2207

Re: Satellite Operator Coordination Certification of Boeing Earth Station Aboard Aircraft (ESAA) License Application.

To Whom it May Concern,

Intelsat confirms and hereby certifies the following with respect to the operations proposed in the above referenced application:

(a). The proposed Ku-band Earth Station Aboard Aircraft (ESAA) operation of The Boeing Company has the potential to create harmful interference to satellite networks adjacent to the target satellite(s) that may be unacceptable;

(b). The power density levels that Boeing provided to this Satellite Operator are consistent with the existing coordination agreements between the IS-907 satellite and the adjacent satellite networks within 6 degrees of orbital separation from the satellite, and

(c). The power density levels of the proposed ESAA operations will be included in future coordination agreements in accordance with FCC rules and regulations.

Please let us know if additional information is required.

Sincerely,

Alan Yates
Senior Technical Advisor,
Spectrum Strategy.

SKY Perfect JSAT Corporation

SKY Perfect JSAT Corporation
1-14-14, Akasaka, Minato-ku
Tokyo 107-0052, Japan
TEL +81-3-5571-7800

September 18, 2014

The Boeing Company
P.O. Box 3707
Seattle, WA 98124-2207

Re: Satellite Operator Coordination Certification of Boeing Earth Station Aboard Aircraft (ESAA) License Application.

To Whom it May Concern,

Sky Perfect JSAT Corporation confirms and hereby certifies the following with respect to the operations proposed in the above referenced application in accordance with section 25.227 paragraph (b)(2) of the Code of Federal Regulations:

(a). The proposed Ku-band Earth Station Aboard Aircraft (ESAA) operation of The Boeing Company has the potential to create harmful interference to satellite networks adjacent to the target satellite(s) that may be unacceptable;

(b). The power density levels that Boeing provided to this Satellite Operator are consistent with the existing coordination agreements between the Superbird-C2 satellite and the adjacent satellite networks within 6 degrees of orbital separation from the satellite, and

(c). The power density levels of the proposed ESAA operations will be included in future coordination agreements.

Please let us know if additional information is required.

Sincerely,

Sky Perfect JSAT Corporation

M. Ishii

Mitsuru Ishii
General Manager
Mobile Business Division
Space & Satellite Business Group

Telesat

TELESAT
1601 Telesat Court
Ottawa, ON, Canada K1B 5P4

EN2014-012
12 September 2014

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

Re: Boeing for earth stations aboard aircraft ("ESAA") terminals

To Whom It May Concern:

This letter certifies Telesat is aware that Boeing is planning to seek authorization from the Federal Communications Commission ("FCC") to operate Ku-band transmit/receive earth stations aboard aircraft ("ESAA") terminals with the T11N satellite at orbital position 37.5W. Specifically, Telesat understands that Boeing seeks to operate three types of Ku-band ESAA terminals consistent with the FCC's Part 25 rules, including Section 25.227.

Boeing operates 3 terminal types on its network (characteristics of which are provided in the appendix below). The system uses a CDMA like waveform with signal spreading to allow for operations of multiple airborne platforms in the same frequency band. Boeing uses an EIRP Spectral Density control algorithm located at the gateway to manage aggregate ESD such that the maximum off axis ESD does not exceed the levels to which the satellite has been coordinated with its neighbors. Boeing has been employing the same ESD control algorithm on Telesat satellites for over 10 years without causing any adverse impacts to Telesat's neighbors. Note that the Boeing ESD control algorithm contains sophisticated Antenna gain models that model the gain pattern of the antenna at all possible skew angles (0 to 180 degrees) and scan angles that could be encountered while operating on the Telesat satellite.

Based on the information provided by Boeing, Telesat (i) acknowledges that the proposed operation of the Boeing ESAA terminals has the potential to create harmful interference to satellite networks adjacent to the T11N satellite that may be unacceptable; (ii) certifies that the power density levels that Boeing provided to Telesat are consistent with the existing coordination agreements between the T11N satellite and the adjacent satellite systems within 6° of orbital separation from T11N, and (iii) confirms that if the FCC authorizes the operations proposed by Boeing, Telesat will take into consideration the power density levels associated with such operations in future satellite network coordination with adjacent satellite operators.

Sincerely,

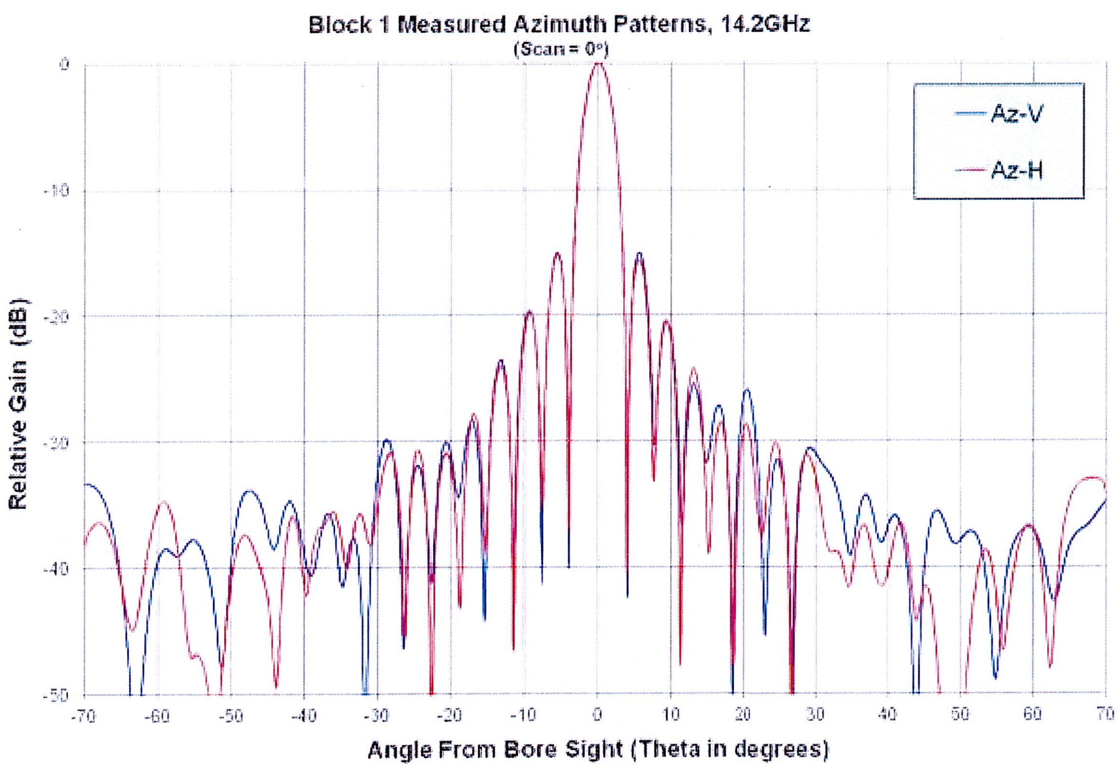
for Randy Gabor

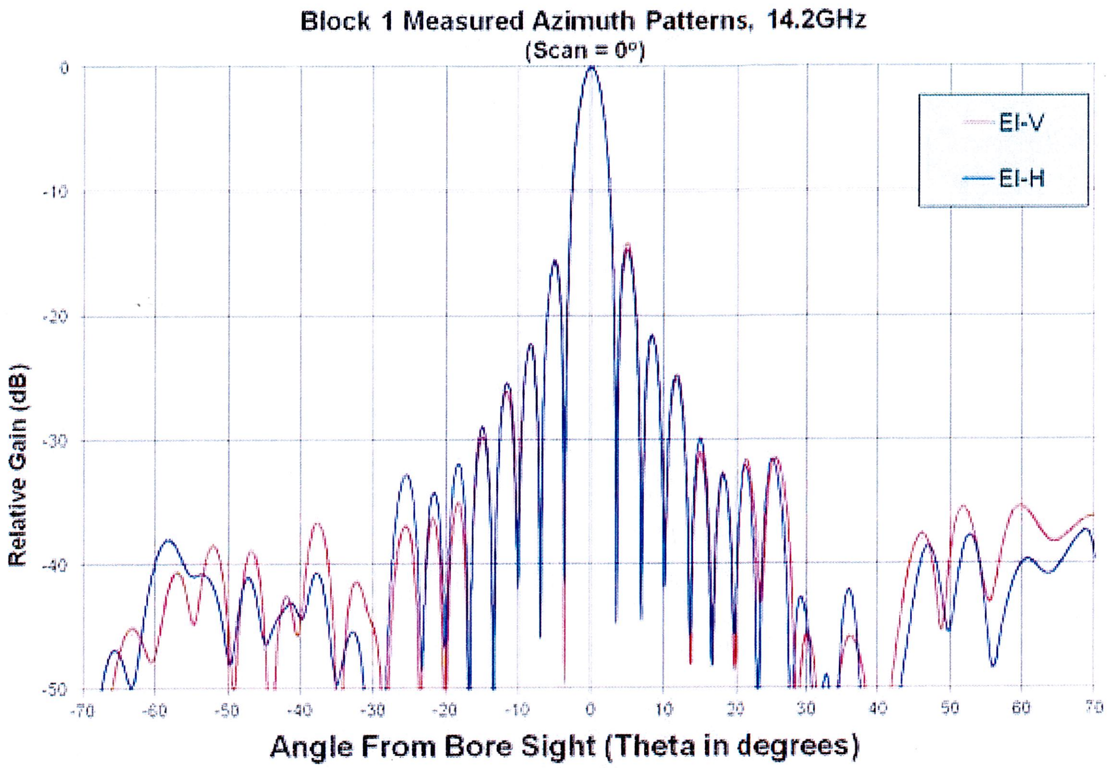
Elisabeth Neasmith, P. Eng
Manager, International Coordination
Department of CTO
TELESAT

Appendix

Block 1 Phased Array Antenna

Specification	Antenna Data
Aperture Dimensions	
Receive	17"x24" (uniform illumination)
Transmit	15" circular (uniform illumination)
Transmit Band	14.0-14.5 GHz
Receive Band	11.45-12.75 GHz
Frequency Tolerance	+/-10 kHz
EIRP	51.2 dBW @ 0o Scan
G/T	12.5 dB/K @ 0o Scan
Transmit Gain	34.9 dBi at 14.2 GHz
Receive Gain	36.7 dBi at 12.0 GHz
Polarization	Linear

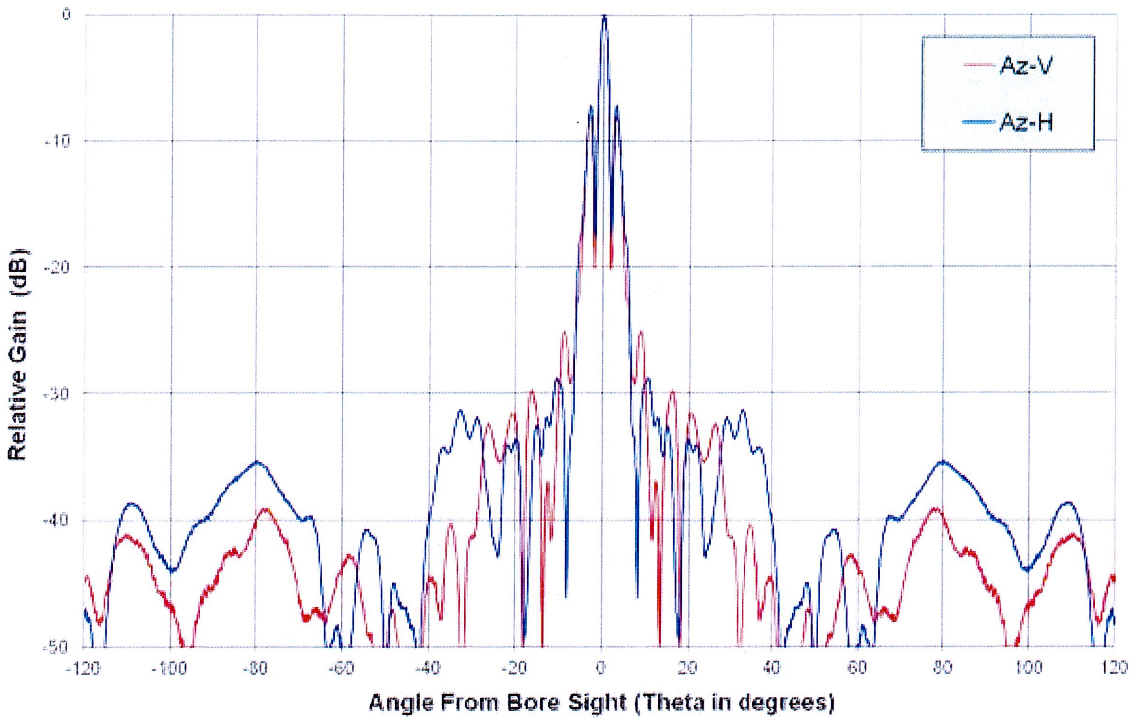




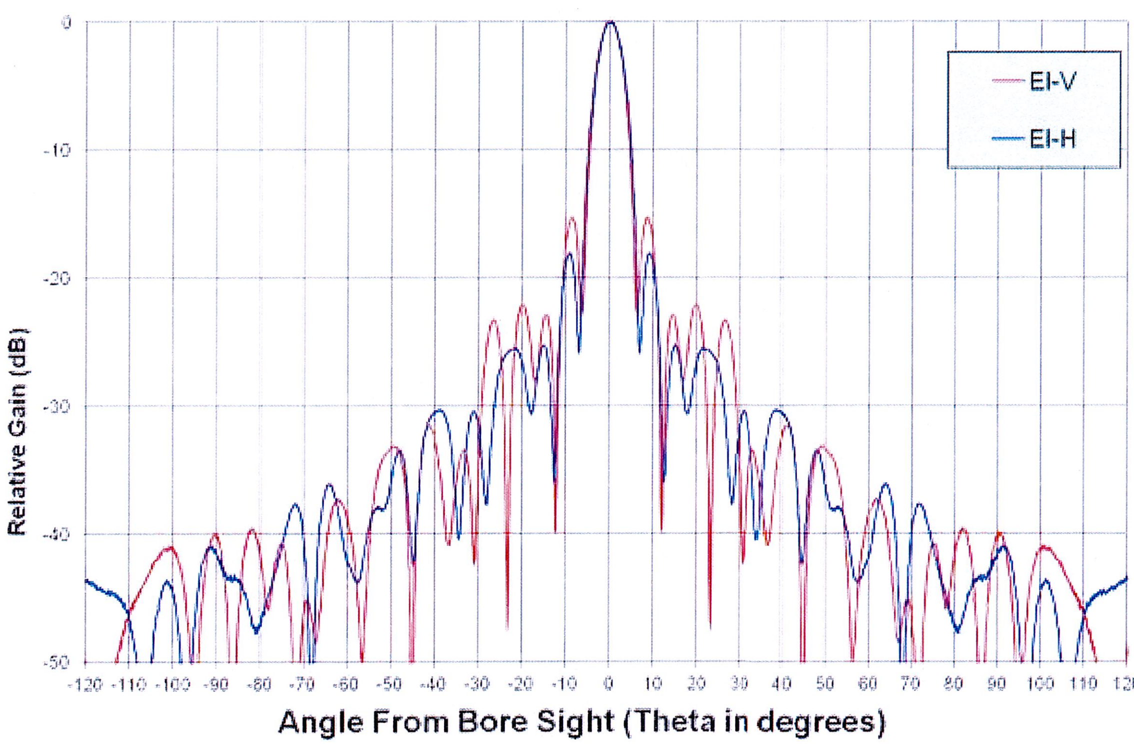
BBM3b MELCO Reflector Antenna

Specification	Antenna Data
Aperture Dimensions	65.0 x 19.6 cm elliptical
Transmit Band	14.0-14.5 GHz
Receive Band	11.2-12.75 GHz
Frequency Tolerance	+/-10 kHz
EIRP	46.7 dBW
G/T	10.5 dB/K
Transmit Gain	33.1 dBi at 14.2 GHz
Receive Gain	31.6 dBi at 12.0 GHz
Polarization	Linear

BBM3b Measured Azimuth Patterns, 14.2GHz



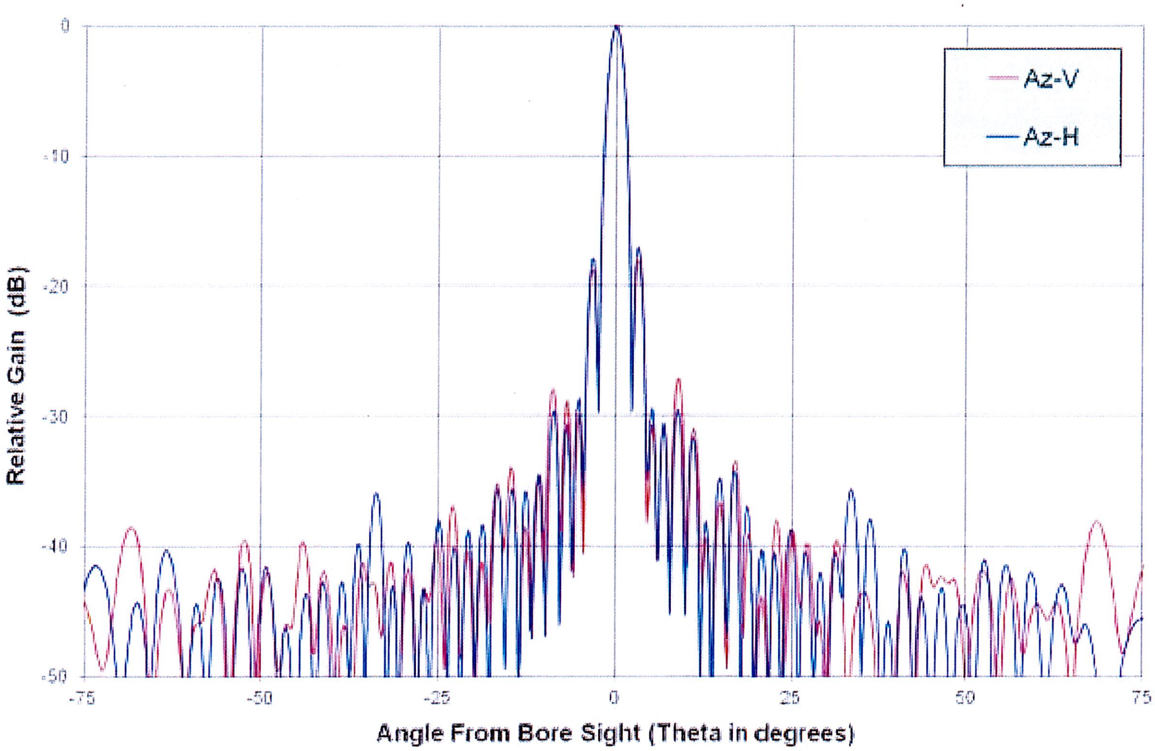
BBM3b Measured Elevation Patterns, 14.2GHz

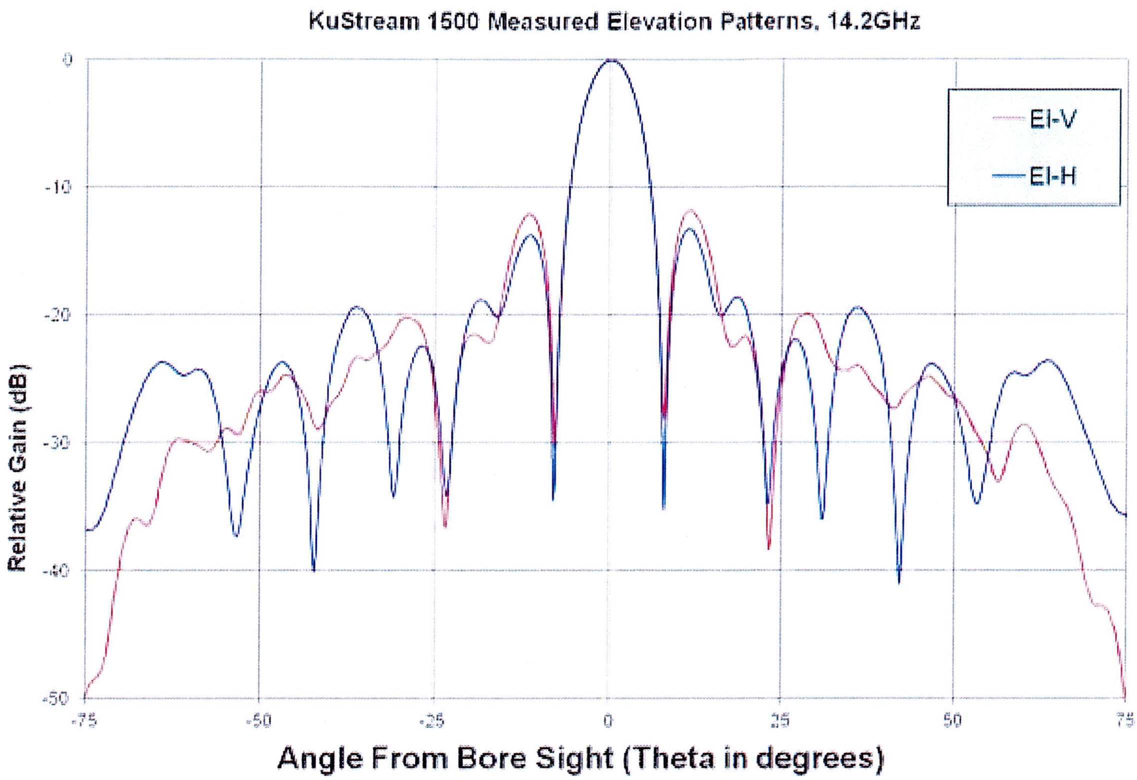


TECOM KuStream 1500 Antenna

Specification	Antenna Data
Aperture Dimensions	65.0 x 17.5 cm rectangular
Transmit Band	14.0-14.5 GHz
Receive Band	11.45-12.75 GHz
Frequency Tolerance	+/-10 kHz
G/T	11.9 dB/K
Transmit Gain	32.5 dBi
Receive Gain	31.5 dBi
EIRP	44.8 dBW
Pointing Error	< 0.2 degrees

KuStream 1500 Measured Azimuth Patterns, 14.2GHz




KuStream 1500 Measured Elevation Patterns, 14.2GHz
El-V
El-H
Relative Gain (dB)
0
-10
-20
-30
-40
-50
-75
-50
-25
0
25
50
75
Angle From Bore Sight (Theta in degrees)