The Boeing Company
Experimental Application

Narrative Statement Providing Complete Program of Research and Experimentation Including Description and Technical Information

Connexion by Boeing[SM] Maritime Earth Stations on Board Vessels

FCC Form 442, Exhibit 1

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Description and Technical Information

1 INTRODUCTION

The Boeing Company ("Boeing") proposes to operate on an experimental basis two types of antennas that may be used in its planned global network of Ku-band earth stations onboard vessels ("ESVs"), called Connexion by Boeing℠ Maritime ("CBBM"), which will provide broadband services to vessel owners, operators, passengers and crew, as well as to other customers in a variety of maritime applications. This testing will allow Boeing to validate potential new communications services in the maritime mobile context. Boeing intends to conduct its experimental operations on a non-harmful interference basis.

Significantly, Boeing currently has experimental special temporary authority ("STA") to operate one of the two antenna types (the Seatel 2403) that is the subject of this application (*See* The Boeing Company, Experimental Special Temporary Authorization, File No. 0703-EX-ST-2004, Call Sign WD2XFK (granted December 13, 2004)). An application for experimental operation on a non-temporary basis with respect to that antenna was filed on December 1, 2004 and remains pending before the Commission. *See* The Boeing Company, Experimental Radio Station Construction Permit and License, FCC File No. 0194-EX-PL-2003, Call Sign WD2XFK (filed December 1, 2004). By this filing, Boeing seeks to amend that application to add a second model of antenna (the Melco RN211709). In addition, the CBBM experimental antennas will operate using the same network control facilities and satellites as the licensed Connexion by Boeing℠ Aeronautical Mobile-Satellite Service ("AMSS") system, and will benefit from the considerable investment made in, and experience Boeing has gained from, operating this network, as shown in Figure 1 below.

As demonstrated herein, granting Boeing's experimental authorization for the Seatel and Melco ESV antennas would not increase the potential for interference into other service from Boeing's experimental operations, and would facilitate the provision of broadband ESV services to maritime customers. As a result, grant of this experimental authorization would serve the public interest, convenience and necessity.

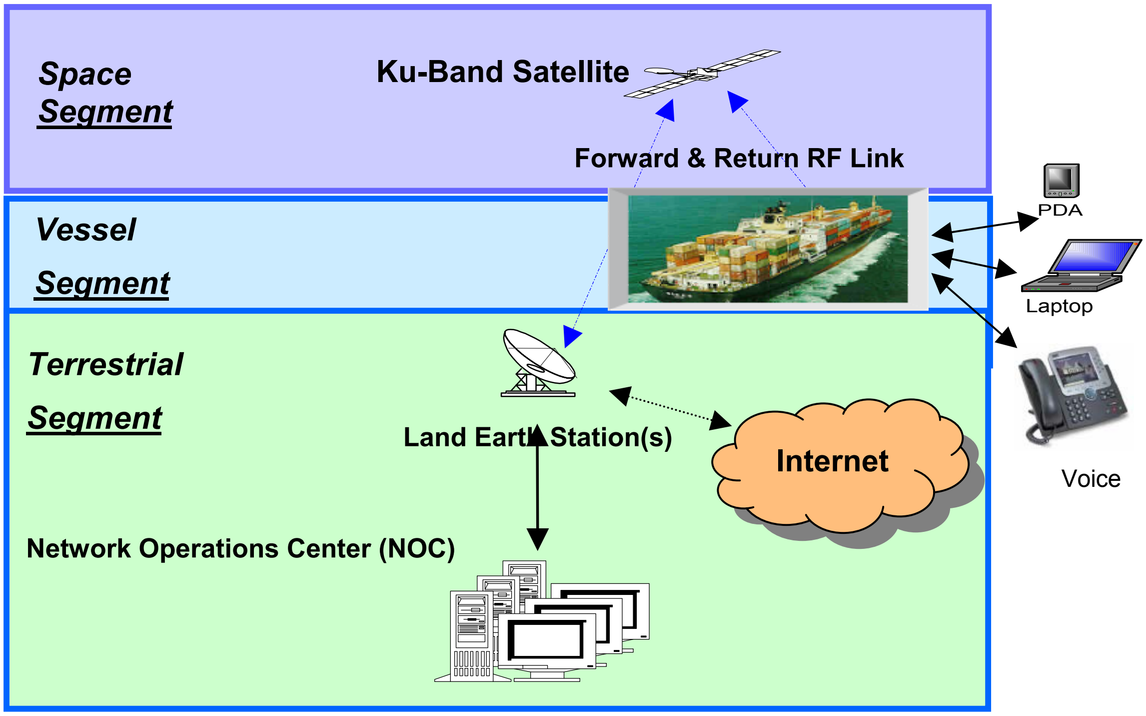

Figure 1 CBBM System Architecture

2 PROPOSED ESV ANTENNA SYSTEMS

Experiments will be conducted using two different antenna models: a 0.6 m reflector antenna and a 1.0 m reflector antenna. This section provides more detailed information on the two ESV antennas that will be used for the CBBM system, the radiofrequency ("RF") link waveform and power spectral density.

2.1 CBBM 0.6 m ESV Antenna

The Seatel 2403 antenna is a 0.6m diameter axially symmetric reflector with a dual-polarized dual-band backfire feed. The antenna is mounted on a 3-axis gimbal to maintain accurate pointing to the satellite, and adjust the plane of polarization for both forward (receive) and return (transmit) links by mechanical rotation of the feed assembly. The antenna is enclosed in a radome designed for low loss in both the transmit and receive bands.

Figure 2. CBBM ESV 0.6 m antenna

Antenna Patterns

The plots provided in Figures 3 and 4 present the measured principal E- and H-plane patterns at mid-band frequencies in the transmit and receive bands (14.2 GHz and 12.0 GHz respectively).

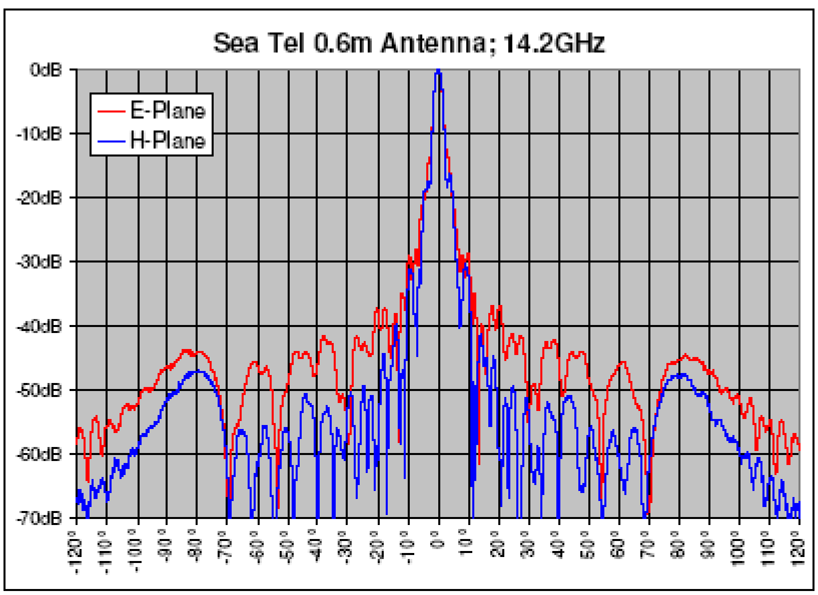

Figure 3. Measured transmit band patterns

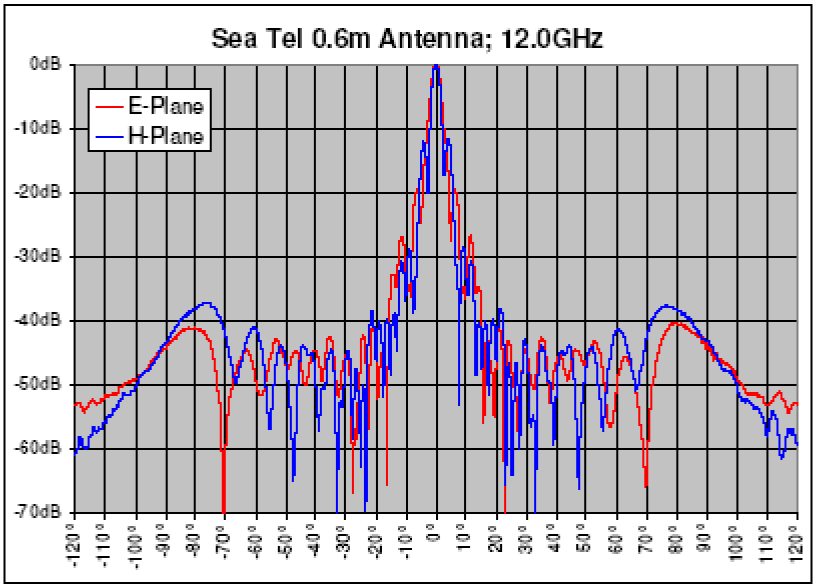

Figure 4. Measured receive band patterns

Antenna parameters	**Specifications**
Aperture Dimensions	60 cm circular
Antenna Beam-width (3 dB)	2.4º
Transmit Band	14.0 GHz to 14.5 GHz
Receive Band	11.2 GHz to 12.75 GHz
Transmit Gain	37.1 dBi
Receive Gain	35.5 dBi
Maximum EIRP	45.0 dBW
Peak ERP	19.5 kW
Maximum G/T	12.4 dB/K
Antenna Polarization	Tx: Single Variable Linear Rx: Dual Orthogonal Linear

Table 1. CBBM 0.6 m antenna characteristics

0.6 m ESV Antenna Pointing Control

"DishScan" is used to spatially track the satellite signal. DishScan moves the antenna beam in a circular path around the line-of-sight to the satellite, with a typical angular displacement of 0.08°. Received signal strength is monitored during this movement which allows the antenna to be positioned to equalize the signal received on all four quadrants of the antenna. In this way, satellite tracking is maintained within accepted industry standards. Polarization tracking is accomplished "open loop," based on knowledge of the satellite and ship locations and the polarization of the satellite transponder. The antenna plane of polarization is adjusted by mechanical rotation of the feed assembly within the reflector.

The antenna scan range is 0-90° in elevation and 360° (continuous) in azimuth. A blanking sector will be defined based on illumination of the ship's mast and other superstructure parts (if any), and the antenna subsystem will be inhibited from transmitting when pointing within this sector.

Stabilization rates exceed 90 degrees per second for the elevation and cross-level axes. Azimuth stabilization exceeds 12 degrees per second with unlimited azimuth capability.

2.2 CBBM 1.0 m ESV Antenna

The CBBM 1.0 m antenna system will use a mechanically steered symmetric parabolic reflector antenna, as shown in Figure 3. The antenna is installed near the top of a vessel, inside a radome, and is designed to track the desired satellite over a large geographic range and through the most extreme movement expected of a vessel.

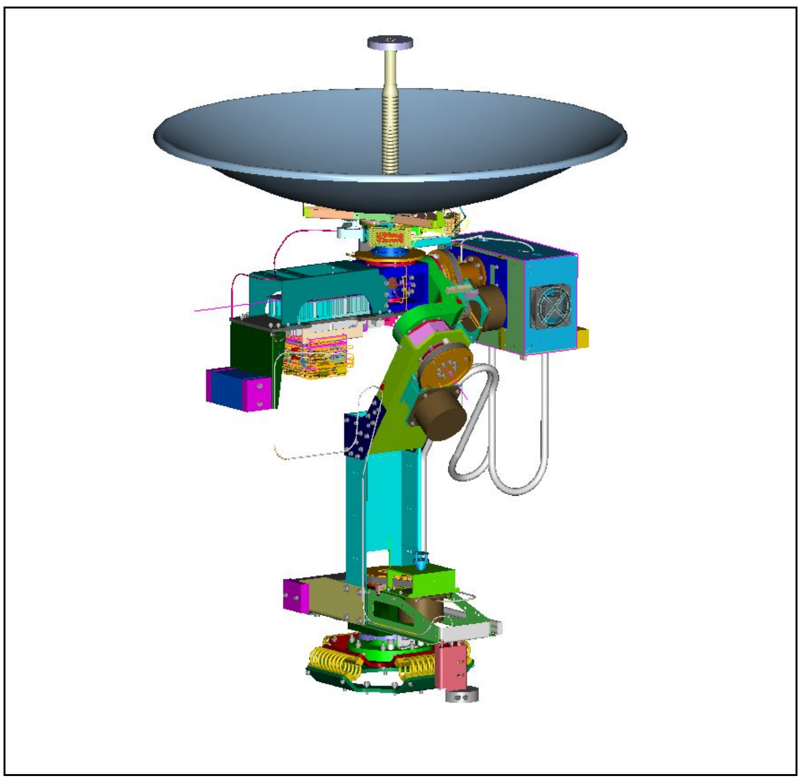

Figure 5. Illustration of a typical CBBM ESV 1.0 m antenna

The CBBM ESV 1.0 m antenna characteristics are summarized in Table 2. The E- and H-plane patterns for this antenna, based on the predicted values are as shown in Figure 6.

Antenna parameters	Specifications
Aperture Dimensions	100 cm circular
Antenna Beam-width (3 dB)	1.6º
Transmit Band	14.0 GHz to 14.5 GHz
Receive Band	11.2 GHz to 12.75 GHz
Transmit Gain	40.7 dBi
Receive Gain	39.3 dBi
Maximum EIRP	46.7 dBW
Peak ERP	28.8 kW
Maximum G/T	16.0 dB/K
Antenna Polarization	Tx: Single Variable Linear Rx: Dual Orthogonal Linear

Table 2. CBBM ESV 1.0 m Antenna Characteristics

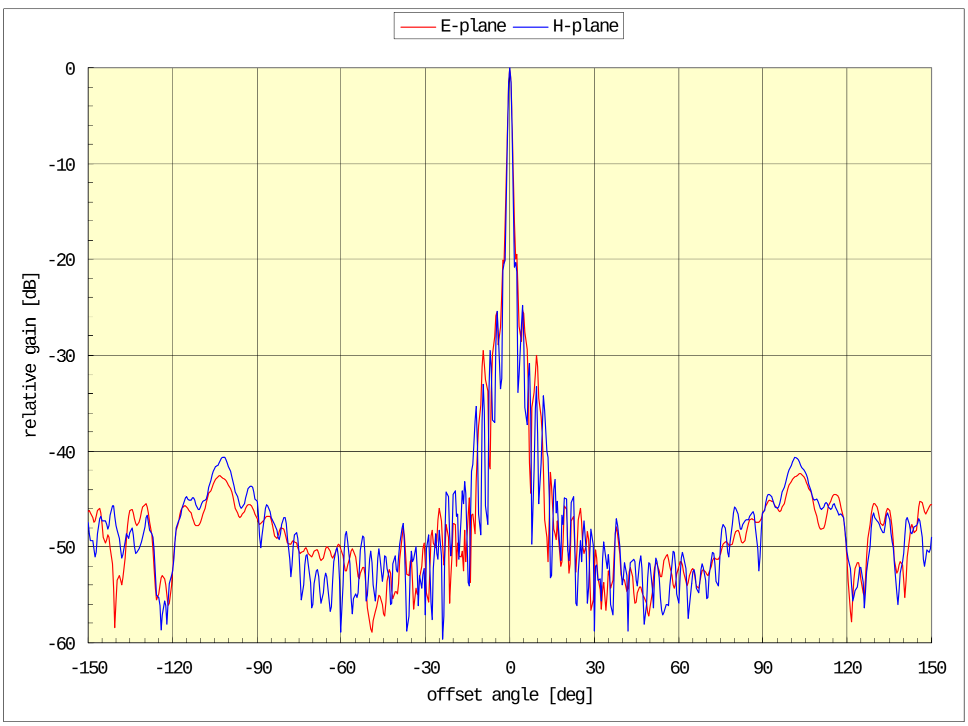

Figure 6. CBBM ESV Antenna radiation patterns (predicted)

1.0 m ESV Antenna Pointing Control

Accurate pointing of transmit and receive beams is achieved by using angular rate sensors, and closed loop conical scan tracking of the RF signal from the satellite by the receive beam. The common receive and transmit reflector aperture provides accurate pointing of the transmit beam.

Spatial acquisition of the satellite RF link is accomplished by means of open loop pointing using ship provided heading data, rate sensor data for pitch and roll motion, and target satellite position data. Following initial acquisition, accurate pointing is achieved by rate sensors mounted on the aperture for rapid compensation of pitch, roll, and yaw motion and flexing of the ship. Correction for errors in spatial acquisition and any bias or drift of the rate sensors is accomplished by continuous conical scanning of the receive beam about the estimated pointing vector to the satellite. Correlation of scan angles with Received Signal Strength Indicator ("RSSI") signals computed by the modem enable high rate correction of the estimated antenna to satellite pointing vector. The RSSI signal is a measure of received satellite signal strength based on output of the receiver filter, and provides robustness against adjacent satellite interference in the receiver bandwidth.

Control of receive and transmit polarization is performed by computing polarization commands based on ship's heading, calculated pitch and roll, satellite location and selected polarization.

2.3 Power Level Monitoring

As described below, the CBBM system effectively monitors and controls the on-axis and off-axis equivalent isotropic radiated power ("e.i.r.p.") from both types of CBBM ESV antennas.

2.3.1 On-Axis e.i.r.p

The on-axis e.i.r.p. of the ESV terminal is ascertained from direct measurement of the RF power delivered to the antenna. The Power Amplifier ("PA") contains a calibrated coupler and a calibrated power detector to measure the power delivered to the output port of the PA. Together with knowledge of the antenna gain and losses downstream of the PA (including the radome loss), the e.i.r.p. of transmitting ESVs be calculated.

2.3.2 Aggregate Off-Axis e.i.r.p

The CBBM system uses a Code Division Multiple Access ("CDMA") transmission scheme, which will permit multiple co-frequency transmissions from different ESVs to be simultaneously received at the same satellite. In order to maintain compatibility with adjacent FSS satellites, the aggregate off-axis e.i.r.p. produced by the all CBB terminals operating on a single frequency will be controlled so as to meet the off-axis e.i.r.p. limits described in Section 5.1.

The aggregate off-axis e.i.r.p. generated by CBBM ESV operations will be computed based on the number of ESVs in a satellite coverage area, the antenna patterns of the ESVs, and the aggregate on-axis e.i.r.p. of the ESVs. The portion of the off-axis e.i.r.p. allocated to ESV operations will vary dynamically based on a bandwidth-on-demand approach (*i.e.*, the aggregate off-axis e.i.r.p. of all transmitting terminals will be continually compared to the applicable off-axis e.i.r.p. limits and, based on how closely the aggregate value approaches the limits, the NOC will issue commands to allow additional ESVs into the network, change ESV data rates/power levels or remove ESVs from the network). In all cases, the aggregate off-axis e.i.r.p. limits set forth in Section 5.1 will be satisfied.

Figures 7 and 8 show the e.i.r.p. spectral density of a single CBBM ESV with respect to the e.i.r.p. spectral limits of 25.222 for the 0.6 m and 1.0 m antennas, respectively.

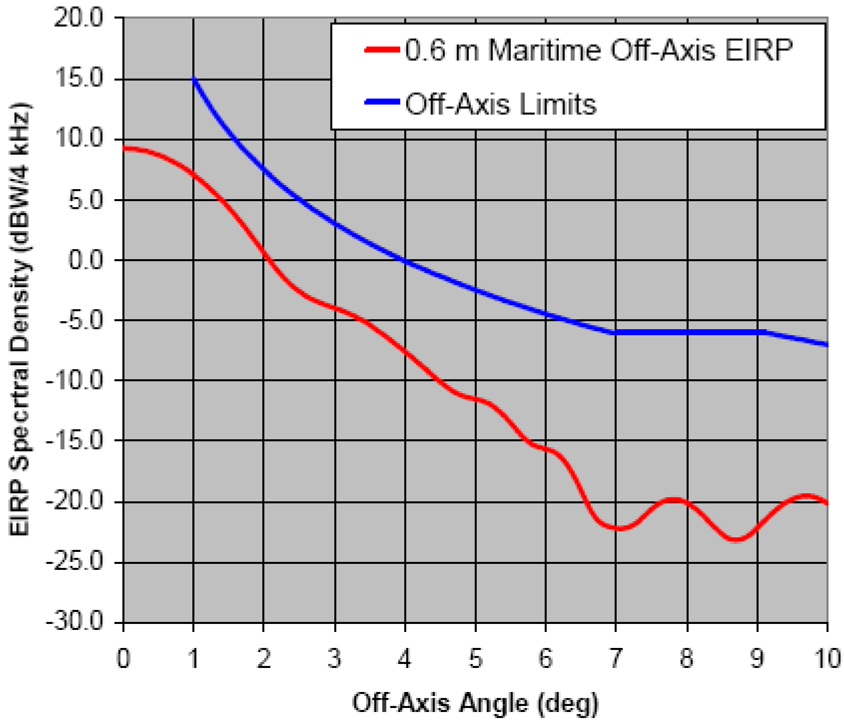

Figure 7. Predicted CBBM 0.6 m antenna e.i.r.p. spectral density

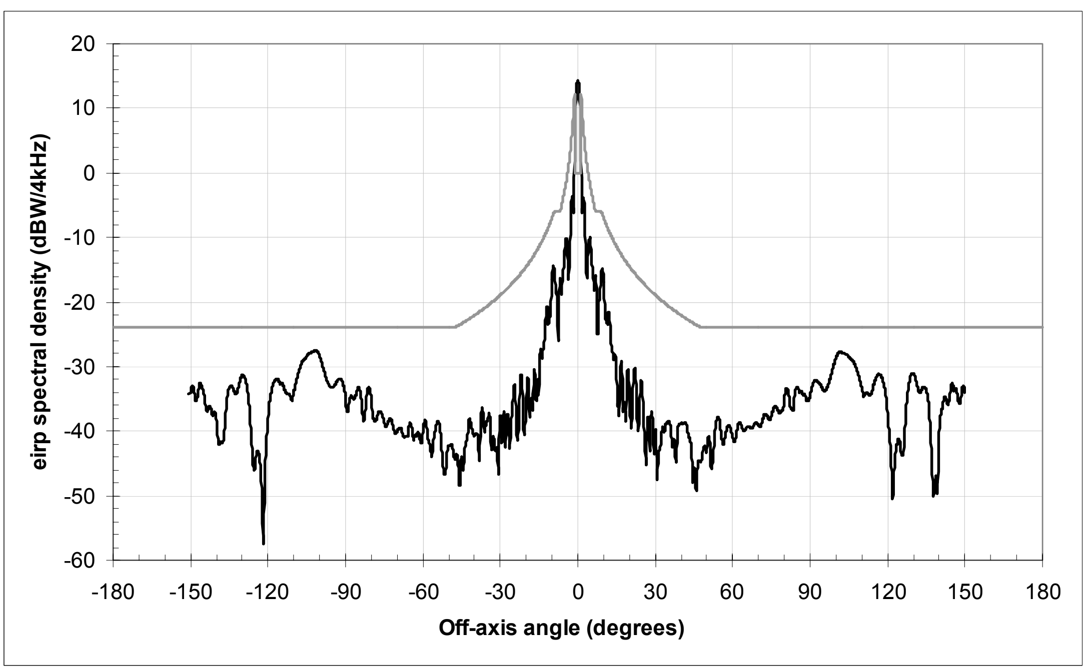

Figure 8. Predicted CBBM 1.0 m antenna e.i.r.p. spectral density

2.4 Waveform Definition

The CBBM system will use identical waveforms to the Connexion by Boeing[SM] AMSS system. Both the forward and return link waveforms use Direct Sequence Spread Spectrum ("DSSS") modulation to reduce the waveform e.i.r.p spectral density. Signals will be spread to 90% of the fraction of the transponder that is used. The waveform characteristics of the CBBM ESV for both the forward and return links are nearly identical and are shown in Table 3.

Typical 3 dB Bandwidth	up to 32.4 MHz
Typical ITU Emission Designation	32M4G7W[1]
Modulation	DSSS / Offset-QPSK
Multiplex Carrier Access Scheme	Forward link: Single carrier with packet multiplexing Return link: Code Division Multiple Access (CDMA)
Filtering	Square Root Raised Cosine (SRRC), $\alpha = 0.35$

Table 3. Waveform Characteristics

2.5 Link Power Spectral Density

On the return link, the maximum uplink e.i.r.p., spectral density from an individual ESV will be between 7.6 dBW/4kHz and 14.4 dBW/4 kHz for return link signal bandwidths between 32.4 MHz and 6.75 MHz. The aggregate uplink e.i.r.p. density for all ESVs sharing a transponder will not exceed approximately 19 dBW/4kHz when operating under the U.S. off-axis e.i.r.p. limits and no more than 31 dBW/4kHz when operating under the off-axis e.i.r.p. limits set forth in Resolution 902.

The downlink e.i.r.p. spectral density from the satellite on the forward link is dependant on the exact satellite e.i.r.p. and spreading bandwidth used for that satellite. For a typical transponder, the down link e.i.r.p. spectral density will not exceed 12 dBW/4 kHz for a typical 32.4 MHz spread signal with an e.i.r.p. of 51 dBW.

3 PROTECTION OF OTHER AUTHORIZED SERVICES

3.1 Fixed-Satellite Service ("FSS")

The CBBM system will protect FSS satellite receivers in the 14.0-14.5 GHz band by controlling the aggregate off-axis e.i.r.p spectral density in the direction of the geostationary arc emitted by ESV antennas as discussed above in Section 4.2.2. When using satellites that have been coordinated for 2-degree spacing and/or to which the Commission's 2-degree spacing rules apply, the CBBM system will meet the off-axis e.i.r.p. limits given by §25.222 (a) (1)-(4):

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[1] This emission designation is based on the spreading bandwidth of 32.4 MHz for a 36 MHz transponder. Fractions of a transponder may be used for forward, or return-link, signals in order to more efficiently utilize space segment resources.

(1) The maximum co-polarized component along the GSO arc of θ degrees from the antenna main beam will not exceed the limits, as given below:

15 – 25log(θ) dBW/4kHz	for 1.25° ≤ θ ≤ 7.0°
-6 dBW/4kHz	for 7.0° < θ ≤ 9.2°
18 – 25log(θ) dBW/4kHz	for 9.2° < θ ≤ 48°
-24 dBW/4kHz	for 48° < θ ≤ 180°

(2) In all other directions, the off-axis EIRP spectral density for co-polarized signals emitted from the ESV shall not exceed the following values:

18 – 25log(θ) dBW/4kHz	for 1.25° ≤ θ ≤ 48°
-24 dBW/4kHz	for 48° < θ ≤ 180°

(3) For θ >7°, the values given in paragraphs (a)(1) of this Section may be exceeded by no more than 10% of the sidelobes, provided no individual sidelobe exceeds the criteria given by more than 3 dB.

(4) In all directions, the off-axis EIRP spectral density for cross-polarized signals emitted from the ESV shall not exceed the following values:

5 - 25log(θ) dBW/4kHz	for 1.8° ≤ θ ≤ 7°
-16 dBW/4kHz	for 7° < θ ≤ 9.2°

Where θ is the angle in degrees from the axis of the main lobe.

When using satellites that have been coordinated for larger orbital spacings and/or where the Commission's 2-degree spacing rules do not apply, the CBBM system will meet the off-axis e.i.r.p. limits coordinated for the serving (target) satellite up to the limits set forth in ITU-R Resolution 902:

14.0-14.5 GHz

Angle off-axis	*Maximum e.i.r.p. in any 40 kHz band*
2° ≤ φ ≤ 7°	33 – 25 log φ dB(W/40 kHz)
7° < φ ≤ 9.2°	12 dB(W/40 kHz)
9.2° < φ ≤ 48°	36 – 25 log φ dB(W/40 kHz)
48° < φ ≤ 180°	–6 dB(W/40 kHz)

Again, the CBBM system will operate within the coordinated values of off-axis e.i.r.p. density for the satellite being used, which may be lower than the values given above.

3.2 Fixed Service ("FS")

The CBBM system will comply with the requirements of Resolution 902 in order to protect co-frequency FS systems. Before operating ESVs on a primary basis within 125 km of the potentially concerned administrations identified in Resolution 902, Annex 1, Boeing will obtain prior agreement for these operations from the concerned administration. However, Boeing expects that in most cases it will be possible to avoid using FS frequencies near concerned administrations.

Previous studies in ITU-R WP 4-9S have shown that the significant factor in determining the minimum distance is the maximum e.i.r.p. towards the horizon, which would be received by the FS system. In Resolution 902 (WRC-03), this is expressed as both a maximum e.i.r.p. level and a maximum e.i.r.p. density towards the horizon. These values of e.i.r.p. towards the horizon are based on the ESVs maximum transmit power at the flange and the gain of the antenna in the direction of the horizon.[2] CBBM emissions will meet both of these criteria and so the CBBM ESV antennas will have an interference effect on the terrestrial services which is no greater than that which would be caused with an antenna size of 1.2 m.

3.3 Radio Astronomy Service ("RAS")

Boeing will coordinate with radio astronomy observatories within line of sight of navigable waters through the National Telecommunications and Information Administration ("NTIA") Interdepartment Radio Advisory Committee ("IRAC") to address potential interference to the RAS observations, as required per §25.222(e).

3.4 Space Research Service ("SRS")

Boeing will coordinate with the operators of space research facilities in line-of-sight of navigable waters to address interference to these receivers as required per §25.222(d).

WDC 368957v1

[2] Preliminary Draft Revision of Recommendation ITU-R SF.1649, Guidance for determination of interference from earth stations on vessels (ESVs) to stations in the fixed service when the ESV is within the minimum distance, ITU-R Document 4-9S/71-E, Annex 4 of Annex 3, 18 May 2005.