

### Exhibit 1

5c: CONUS, see exhibit 2

6a: The bore site beamwidth is 3.1° and it spreads to approximately 6° at 60° off of bore site.

6b: parallel to Horizontal plane

6c: Varies dependent on aircraft orientation and electric scanning

|     |                     |                                                   |               |
|-----|---------------------|---------------------------------------------------|---------------|
| 13: | <u>Manufacturer</u> | <u>Model</u>                                      | <u>Number</u> |
|     | Boeing              | Transmit Phased Array Antenna (TxPAA) Prototype   | 8             |
|     | Boeing              | TxPAA Controller Prototype                        | 8             |
|     | Boeing              | TxPAA Power Supply Prototype                      | 8             |
|     | SSE Telecom         | K-Star 2 watt Transceiver Model OM 042398         | 8             |
|     | L3 Communications   | Spread Spectrum Modem VME form factor model EB200 | 8             |
|     | SBS GreenSpring     | IP-Reed Solomon Card, Model 91411921              | 8             |

**EXHIBIT 2 of FCC FORM 422 Question 10.**

This narrative statement will describe in detail the following:

- (a) The complete program of research and experimentation proposed including description of equipment and theory of operation.
- (b) The specific objectives to be accomplished
- (c) How the program of experimentation has a reasonable promise of contribution to the development extension, expansion or utilization of the radio art, or in along lines not already investigated.

**Introduction:**

Commercial airlines and military services have expressed a desire for two-way data communications while in transit. As a major supplier of aircraft, Boeing is interested in providing this service to its customers. Once developed, the technology would be useful for any mobile platform in need of two-way data communications. There are two ways to approach this problem.

The first is to construct a network of ground stations that can provide continuous coverage anywhere in the continental United States (CONUS). This approach requires a large investment to construct the necessary infrastructure for desired coverage.

A second approach is to provide the service via satellite. Ku-band FSS Satellites provide worldwide terrestrial and limited maritime coverage with sufficient power to enable high rate data communications. Transponders on these satellites may be leased/purchased at a significantly lower cost than the development of a ground-based network.

Boeing currently manufactures phased array receive antennas for operation with Ku-band FSS and BSS satellites. This system receives information broadcasts anywhere within CONUS at data rates greater than 1.5 Mbps. Customers can receive cable television as well as data transmissions. The low profile array and external mounting hardware virtually eliminate impact to the aerodynamic performance of the platform and all support hardware is installed inside the structure, allowing environmental control and maintenance access.

To satisfy the two-way communication requirement, a data downlink capability is needed from the platform to the ground station. In order to transmit, the antenna's beam must not interfere with satellites on either side of the target satellite. The 2° orbital spacing of FSS satellites makes this rather difficult. A small antenna that does not conform to the requirements of CFR, title 47, part 25.209 (a) and (b) can be used, provided that it is shown that unacceptable levels of interference will not be caused under conditions of uniform 2° orbital spacing. ITU radio regulations, appendix 29 provides a method of determining a level of acceptable interference not requiring coordination.

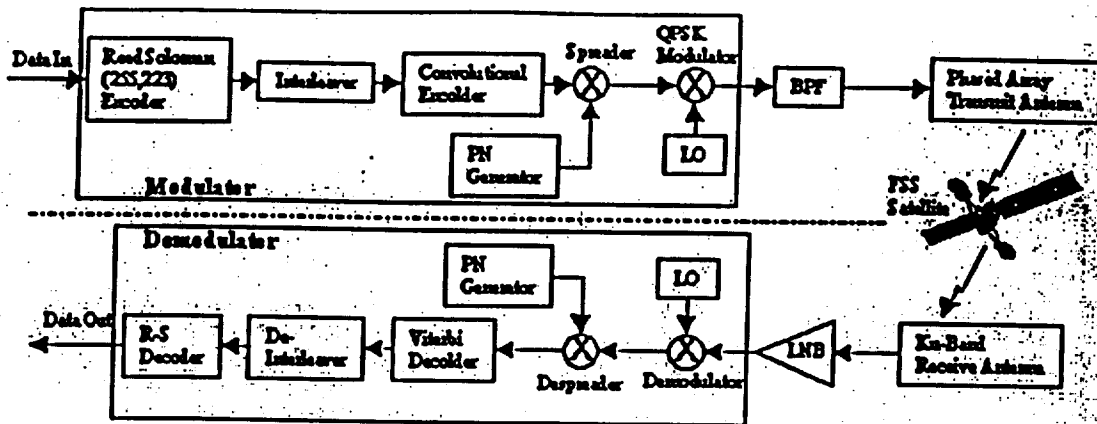
**Objective:**

The objective of this experiment is to develop a high data rate, satellite information transmission system to use on mobile platforms. A small aperture Boeing Ku-band phased array antenna will be used to transmit a direct spread spectrum modulated signal. This transmit system will lower the power spectral density to within acceptable interference levels at adjacent satellites.

The system will be similar to the Qualcomm OmniTRACS system that utilizes Ku-band FSS satellites for mobile communications with truck fleets.

**Approach:**

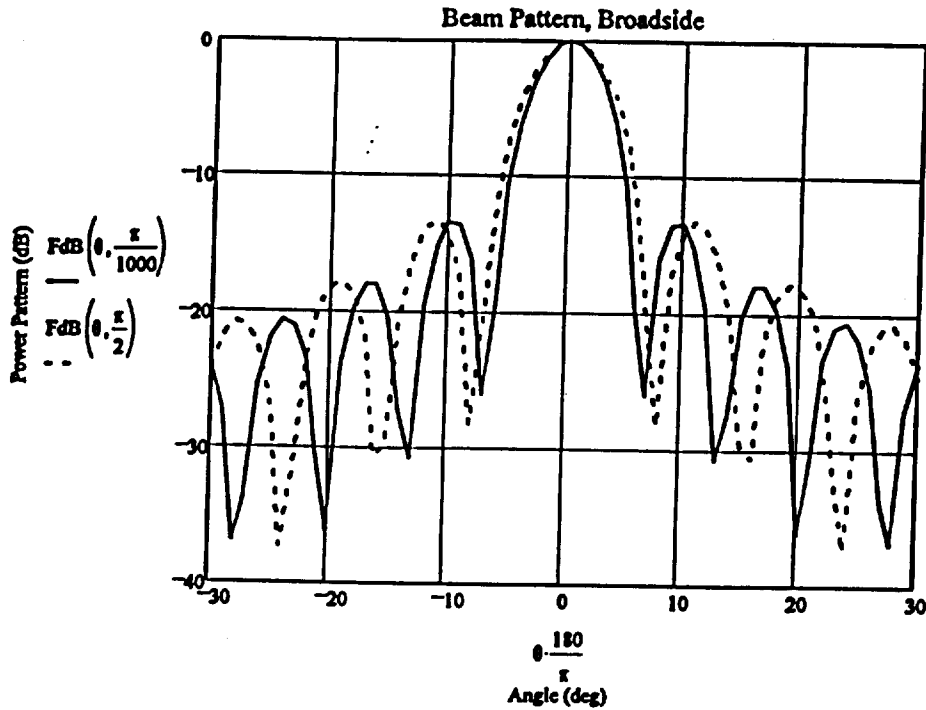
A block diagram of the proposed experimental system is shown in Figure 1. The input data is encoded with a concatenated forward error correction (FEC) coding scheme improve the receiver  $E_b/N_0$ . The outer code is a Reed-Solomon (RS) (255, 223) code.



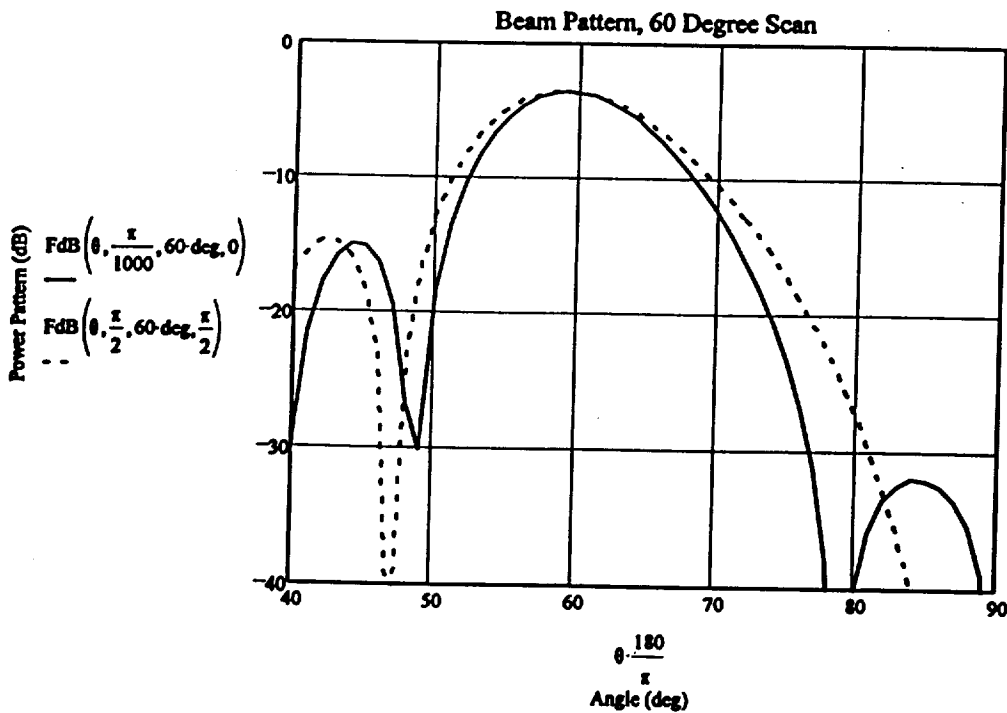
**Figure 1 Experimental Transmit System Block Diagram**

Given an input data rate of 256 kbps, following the FEC, the coded data rate is 585 kbps and the signal is direct-sequence spread by a factor of 274. The spread signal is QPSK modulated, band-pass filtered at the first spectral null producing a spectral occupancy of about 20 MHz, and transmitted with a phased array antenna.

The transmit antenna is a 254 element phased array. It is approximately 8" x 13.5" x 1.5" and has a broadside 3 dB beamwidth of 6 degrees. When the antenna is scanned to its maximum scan angle the beamwidth is 12 degrees. Figures 2 and 3 are plots of the anticipated beam patterns for the broadside beam and for the maximum angle scanned beam. As can be seen from the beam patterns, there is no appreciable signal interference for signals into the adjacent satellites at a 2° orbital spacing. The spectrum spreading technique is used to reduce the PSD to a level that does not cause unacceptable interference into the adjacent satellite.



**Figure 2 Beam Pattern for Transmit Antenna at Broadside**  
 Solid line shows pattern for  $\phi=0^\circ$  cut. Dashed line shows pattern for  $\phi=90^\circ$  cut.



**Figure 3 Beam Pattern for Transmit Antenna at Maximum Scan Angle**

Solid line shows pattern for  $\phi=0^\circ$  cut and scanned to  $(\theta, \phi)=(60, 0)$ . Dashed line shows pattern for  $\phi=90^\circ$  cut and scanned to  $(\theta, \phi)=(60, 90)$ .

## Appendix C Link Budgets

**Table C-1 IDS Forward Feeder Link Budget**

| Forward Feeder-Link          |           | Clear      | Rain-up    |
|------------------------------|-----------|------------|------------|
| Transmit Frequency           | GHz       | 13.00      | 13.00      |
| Transmitter Power            | W         | 0.045      | 0.41       |
| Transmit Antenna Gain (Peak) | dB        | 53.5       | 53.5       |
| Hpa/Antenna Line Losses      | dB        | -1.1       | -1.1       |
| Transmit EIRP                | dBW       | 39.0       | 48.6       |
| Elevation Angle              | Degrees   | 10.0       | 10.0       |
| Path Loss                    | dB        | -202.6     | -202.6     |
| Atmospheric Loss             | dB        | -0.7       | -0.7       |
| Rain Loss                    | dB        | 0.0        | -8.4       |
| Receive Antenna Gain         | dB        | 40.5       | 40.5       |
| Receive System Noise Temp    | K         | 450.6      | 450.6      |
| Receiver Losses              | dB        | -0.5       | -0.5       |
| Received Power               | dB W      | -124.8     | -123.6     |
| Satellite Antenna G/T        | dB/K      | 12.9       | 12.9       |
| Noise Bandwidth              | dB-Hz     | 67.2       | 67.2       |
| C/N                          | dB        | 10.1       | 11.3       |
| C/I (Intra-System)           | dB        | 20.2       | 13.5       |
| C/I (GSO Networks)           | dB        | 17.3       | 18.5       |
| C/I (Other NGSO Networks)    | dB        | 15.0       | 16.2       |
| <b>Total C/(N+I)</b>         | <b>dB</b> | <b>8.0</b> | <b>8.0</b> |
| <b>Required C/(N+I)</b>      | <b>dB</b> | <b>7.0</b> | <b>7.0</b> |
| <b>Margin</b>                | <b>dB</b> | <b>1.0</b> | <b>1.0</b> |

**Table C-2 IDS Forward Service Link Budgets**  
This link budget is for the nadir pointed beam, Beam 00

| Forward Service-Link Beam 00     |           | Clear      | Rain       |
|----------------------------------|-----------|------------|------------|
| Transmit Frequency               | GHz       | 12.2       | 12.2       |
| Transmitter Power                | Watts     | 10.5       | 10.5       |
| Transmit Antenna Gain (Beam EOC) | dB        | 25.0       | 25.0       |
| Hpa/Antenna Line Losses          | dB        | -1.0       | -1.0       |
| Transmit EIRP                    | dBW       | 34.2       | 34.2       |
| Elevation Angle (Beam EOC)       | Degrees   | 78.5       | 78.5       |
| Path Loss (Clear Sky)            | dB        | -200.3     | -200.3     |
| Atmospheric Loss                 | dB        | -0.1       | -0.1       |
| Rain Loss                        | dB        | 0.0        | -1.3       |
| Receive Antenna Gain             | dB        | 36.1       | 36.1       |
| Receiver Losses                  | dB        | -0.5       | -0.5       |
| Received Power                   | dBW       | -130.6     | -131.9     |
| Data Rate                        | dB-Hz     | 67.2       | 67.2       |
| Eb                               | dBW/Hz    | -197.8     | -199.1     |
| Receive System Noise Temp        | K         | 231.2      | 292.0      |
| No                               | dBW/Hz    | -205.0     | -203.9     |
| Eb/No                            | dB        | 7.2        | 4.9        |
| Eb/No (Intra-System)             | dB        | 23.0       | 23.0       |
| Eb/No (GSO Networks)             | dB        | 16.7       | 15.5       |
| Eb/No (Other NGSO Networks)      | dB        | 16.0       | 14.7       |
| <b>Total Eb/(No+Io)</b>          | <b>dB</b> | <b>6.1</b> | <b>4.1</b> |
| <b>Required Eb/No</b>            | <b>dB</b> | <b>3.0</b> | <b>3.0</b> |
| <b>Margin</b>                    | <b>dB</b> | <b>3.1</b> | <b>1.1</b> |

**Table C-3 IDS Forward Service Link Budgets**  
This link budget is for the edge of coverage beam, Beam 30

| Forward Service-Link Beam 30     |           | Clear      | Rain       |
|----------------------------------|-----------|------------|------------|
| Transmit Frequency               | GHz       | 12.2       | 12.2       |
| Transmitter Power                | Watts     | 26.3       | 26.3       |
| Transmit Antenna Gain (Beam EOC) | dB        | 28.0       | 28.0       |
| Hpa/Antenna Line Loses           | dB        | -1.0       | -1.0       |
| Transmit EIRP                    | dBW       | 41.2       | 41.2       |
| Elevation Angle (Beam EOC)       | degrees   | 30.0       | 30.0       |
| Path Loss (Clear Sky)            | dB        | -201.3     | -201.3     |
| Atmospheric Loss                 | dB        | -0.2       | -0.2       |
| Rain Loss                        | dB        | 0.0        | -2.5       |
| Receive Antenna Gain             | dB        | 32.0       | 32.0       |
| Receiver Losses                  | dB        | -0.5       | -0.5       |
| Received Power                   | dBW       | -128.8     | -131.3     |
| Data Rate                        | dB-Hz     | 67.2       | 67.2       |
| Eb                               | dBW/Hz    | -196.0     | -198.5     |
| Receive System Noise Temp        | K         | 237.1      | 339.2      |
| No                               | dBW/Hz    | -204.9     | -203.3     |
| Eb/No                            | dB        | 8.8        | 4.8        |
| Eb/Io (Intra-System)             | dB        | 23.0       | 22.8       |
| Eb/Io (GSO Networks)             | dB        | 18.5       | 16.0       |
| Eb/Io (Other NGSO Networks)      | dB        | 17.8       | 15.3       |
| <b>Total Eb/(No+Io)</b>          | <b>dB</b> | <b>7.8</b> | <b>4.1</b> |
| <b>Required Eb/No</b>            | <b>dB</b> | <b>3.0</b> | <b>3.0</b> |
| <b>Margin</b>                    | <b>dB</b> | <b>4.8</b> | <b>1.1</b> |

**Table C-4 IDS Return Link Budget**  
This link budget is for the nadir pointed beam, Beam 00

| Return Link Beam 00                  |        | Clear  | Rain-up | Rain-down | Rain-both |
|--------------------------------------|--------|--------|---------|-----------|-----------|
| <b>Uplink</b>                        |        |        |         |           |           |
| Transmit Frequency                   | GHz    | 14.05  | 14.05   | 14.05     | 14.05     |
| Transmitter Power                    | Watts  | 13.3   | 20.6    | 13.3      | 20.6      |
| Transmit Antenna Gain                | dB     | 32.4   | 32.4    | 32.4      | 32.4      |
| Hpa/Antenna Line Losses              | dB     | -1.3   | -1.3    | -1.3      | -1.3      |
| Transmit EIRP                        | dBW    | 42.3   | 44.2    | 42.3      | 44.2      |
| Elevation Angle (Beam EOC)           | °      | 78.5   | 78.5    | 78.5      | 78.5      |
| Path Loss (Clear Sky)                | dB     | -201.5 | -201.5  | -201.5    | -201.5    |
| Atmospheric Loss                     | dB     | -0.1   | -0.1    | -0.1      | -0.1      |
| Rain Loss                            | dB     | 0.0    | -1.9    | 0.0       | -1.9      |
| Receive Antenna Gain (Beam EOC)      | dB     | 25.0   | 25.0    | 25.0      | 25.0      |
| Receiver Losses                      | dB     | -1.0   | -1.0    | -1.0      | -1.0      |
| Received Power                       | dBW    | -135.3 | -135.3  | -135.3    | -135.3    |
| Data Rate                            | dB-Hz  | 48.9   | 48.9    | 48.9      | 48.9      |
| Eb                                   | dBW/Hz | -184.2 | -184.2  | -184.2    | -184.2    |
| Receive System Noise Temp            | K      | 453.1  | 453.1   | 453.1     | 453.1     |
| No                                   | dBW/Hz | -202.0 | -202.0  | -202.0    | -202.0    |
| Eb/No (Uplink)                       | dB     | 17.8   | 17.8    | 17.8      | 17.8      |
| Number Of Simultaneous Users         |        | 48.0   | 48.0    | 48.0      | 48.0      |
| Interference Bandwidth               | dB-Hz  | 72.9   | 72.9    | 72.9      | 72.9      |
| Eb/Io (Multiple Access Interference) | dB     | 7.4    | 7.4     | 7.4       | 7.4       |
| Eb/Io (Other Intra-System)           | dB     | 21.4   | 21.4    | 21.4      | 21.4      |
| Eb/Io (GSO Interference)             | dB     | 25.4   | 26.3    | 25.4      | 26.3      |
| Eb/Io (Other NGSO)                   | dB     | 15.0   | 15.0    | 15.0      | 15.0      |
| Eb/(No+Io) (Uplink)                  | dB     | 6.2    | 6.2     | 6.2       | 6.2       |



**Ku-Band NGSO FSS System**  
January 1999

| Return Link Beam 00         |           | Clear      | Rain-up    | Rain-down  | Rain-both  |
|-----------------------------|-----------|------------|------------|------------|------------|
| <b>Downlink</b>             |           |            |            |            |            |
| Transmit Frequency          | GHz       | 11.2       | 11.2       | 11.2       | 11.2       |
| Transmitter Power           | Watts     | 0.003      | 0.003      | 0.025      | 0.025      |
| Transmit Antenna Gain       | dB        | 39.2       | 39.2       | 39.2       | 39.2       |
| Hpa/Antenna Line Losses     | dB        | -1.0       | -1.0       | -1.0       | -1.0       |
| Transmit EIRP               | dBW       | 12.9       | 12.9       | 22.1       | 22.1       |
| Elevation Angle             | Degrees   | 10.0       | 10.0       | 10.0       | 10.0       |
| Path Loss (Clear Sky)       | dB        | -201.3     | -201.3     | -201.3     | -201.3     |
| Atmospheric Loss            | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Rain Loss                   | dB        | 0.0        | 0.0        | -6.7       | -6.7       |
| Receive Antenna Gain        | dB        | 52.2       | 52.2       | 52.2       | 52.2       |
| Receiver Losses             | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Received Power              | dBW       | -137.2     | -137.2     | -134.7     | -134.7     |
| Data Rate                   | dB-Hz     | 48.9       | 48.9       | 48.9       | 48.9       |
| Eb                          | dBW/Hz    | -186.0     | -186.0     | -183.5     | -183.5     |
| Receive System Noise Temp   | K         | 198.7      | 198.7      | 343.0      | 343.0      |
| No                          | dBW/Hz    | -205.6     | -205.6     | -203.2     | -203.2     |
| Eb/No (Downlink)            | dB        | 19.6       | 19.6       | 19.7       | 19.7       |
| Eb/Io (Intra-System)        | dB        | 27.1       | 27.1       | 21.4       | 21.4       |
| Eb/Io (GSO Networks)        | dB        | 19.8       | 19.8       | 22.3       | 22.3       |
| Eb/Io (Other NGSO Networks) | dB        | 19.6       | 19.6       | 19.6       | 19.6       |
| Eb/(No+Io) (Downlink)       | dB        | 14.6       | 14.6       | 14.6       | 14.6       |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>5.6</b> | <b>5.6</b> | <b>5.6</b> | <b>5.6</b> |
| <b>Required Eb/No</b>       | <b>dB</b> | <b>4.3</b> | <b>4.3</b> | <b>4.3</b> | <b>4.3</b> |
| <b>Margin</b>               | <b>dB</b> | <b>1.3</b> | <b>1.3</b> | <b>1.3</b> | <b>1.3</b> |

**Table C-5 IDS Return Link Budget**  
 This link budget is for the edge of coverage beam, Beam 30

| Return Link Beam 30                  |        | Clear  | Rain-up | Rain-down | Rain-both |
|--------------------------------------|--------|--------|---------|-----------|-----------|
| <b>Uplink</b>                        |        |        |         |           |           |
| Transmit Frequency                   | GHz    | 14.05  | 14.05   | 14.05     | 14.05     |
| Transmitter Power                    | Watts  | 28.7   | 67.7    | 28.7      | 67.7      |
| Transmit Antenna Gain (Beam EOC)     | dB     | 27.2   | 27.2    | 27.2      | 27.2      |
| Hpa/Antenna Line Losses              | dB     | -1.3   | -1.3    | -1.3      | -1.3      |
| Transmit EIRP                        | dBW    | 40.5   | 44.2    | 40.5      | 44.2      |
| Elevation Angle (Beam EOC)           | °      | 30.0   | 30.0    | 30.0      | 30.0      |
| Path Loss (Clear Sky)                | dB     | -202.5 | -202.5  | -202.5    | -202.5    |
| Atmospheric Loss                     | dB     | -0.3   | -0.3    | -0.3      | -0.3      |
| Rain Loss                            | dB     | 0.0    | -3.7    | 0.0       | -3.7      |
| Receive Antenna Gain                 | dB     | 28.0   | 28.0    | 28.0      | 28.0      |
| Receiver Losses                      | dB     | -1.0   | -1.0    | -1.0      | -1.0      |
| Received Power                       | dBW    | -135.3 | -135.3  | -135.3    | -135.3    |
| Data Rate                            | dB-Hz  | 48.9   | 48.9    | 48.9      | 48.9      |
| Eb                                   | dBW/Hz | -184.2 | -184.2  | -184.2    | -184.2    |
| Receive System Noise Temp            | K      | 453.1  | 453.1   | 453.1     | 453.1     |
| No                                   | dBW/Hz | -202.0 | -202.0  | -202.0    | -202.0    |
| Eb/No (Uplink)                       | dB     | 17.8   | 17.8    | 17.8      | 17.8      |
| Number Of Simultaneous Users         |        | 48.0   | 48.0    | 48.0      | 48.0      |
| Interference Bandwidth               | dB-Hz  | 72.9   | 72.9    | 72.9      | 72.9      |
| Eb/Io (Multiple Access Interference) | dB     | 7.4    | 7.4     | 7.4       | 7.4       |
| Eb/Io (Other Intra-System)           | dB     | 21.4   | 21.0    | 21.4      | 21.0      |
| Eb/Io (GSO Networks)                 | dB     | 27.3   | 27.3    | 27.3      | 27.3      |
| Eb/Io (Other NGSO Networks)          | dB     | 15.0   | 15.0    | 15.0      | 15.0      |
| Eb/(No+Io) (Uplink)                  | dB     | 6.2    | 6.2     | 6.2       | 6.2       |

| Return Link Beam 30         |           | Clear      | Rain-up    | Rain-down  | Rain-both  |
|-----------------------------|-----------|------------|------------|------------|------------|
| <b>Downlink</b>             |           |            |            |            |            |
| Transmit Frequency          | GHz       | 11.2       | 11.2       | 11.2       | 11.2       |
| Transmitter Power           | Watts     | 0.003      | 0.003      | 0.025      | 0.025      |
| Transmit Antenna Gain       | dB        | 39.2       | 39.2       | 39.2       | 39.2       |
| Hpa/Antenna Line Losses     | dB        | -1.0       | -1.0       | -1.0       | -1.0       |
| Transmit EIRP               | dBW       | 12.9       | 12.9       | 22.1       | 22.1       |
| Elevation Angle             | Degrees   | 10.0       | 10.0       | 10.0       | 10.0       |
| Path Loss (Clear Sky)       | dB        | -201.3     | -201.3     | -201.3     | -201.3     |
| Atmospheric Loss            | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Rain Loss                   | dB        | 0.0        | 0.0        | -6.7       | -6.7       |
| Receive Antenna Gain        | dB        | 52.2       | 52.2       | 52.2       | 52.2       |
| Receiver Losses             | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Received Power              | dBW       | -137.2     | -137.2     | -134.7     | -134.7     |
| Data Rate                   | dB-Hz     | 48.9       | 48.9       | 48.9       | 48.9       |
| Eb                          | dBW/Hz    | -186.0     | -186.0     | -183.5     | -183.5     |
| Receive System Noise Temp   | K         | 198.7      | 198.7      | 343.0      | 343.0      |
| No                          | dBW/Hz    | -205.6     | -205.6     | -203.2     | -203.2     |
| Eb/No (Downlink)            | dB        | 19.6       | 19.6       | 19.7       | 19.7       |
| Eb/No (Intra-System)        | dB        | 27.1       | 27.1       | 21.4       | 21.4       |
| Eb/No (GSO Networks)        | dB        | 19.8       | 19.8       | 22.3       | 22.3       |
| Eb/No (Other NGSO Networks) | dB        | 19.6       | 19.6       | 19.6       | 19.6       |
| Eb/(No+No) (Downlink)       | dB        | 14.6       | 14.6       | 14.6       | 14.6       |
| <b>Total Eb/No</b>          | <b>dB</b> | <b>5.6</b> | <b>5.6</b> | <b>5.6</b> | <b>5.6</b> |
| <b>Required Eb/No</b>       | <b>dB</b> | <b>4.3</b> | <b>4.3</b> | <b>4.3</b> | <b>4.3</b> |
| <b>Margin</b>               | <b>dB</b> | <b>1.4</b> | <b>1.3</b> | <b>1.4</b> | <b>1.3</b> |

**Table C-6 TT&C Command Link Budget**

| Command Uplink                |         | Feeder link<br>Antenna | Omni<br>Antenna |
|-------------------------------|---------|------------------------|-----------------|
| Transmit Frequency            | GHz     | 14.0                   | 14.0            |
| Transmit EIRP                 | dBW     | 43.0                   | 83.1            |
| Elevation Angle               | degrees | 10.0                   | 10.0            |
| Free Space Path Loss          | dB      | -203.2                 | -203.2          |
| Atmospheric Loss              | dB      | -0.7                   | -0.7            |
| Rain Loss                     | dB      | -9.8                   | -9.8            |
| Polarization Loss             | dB      | -0.1                   | -0.1            |
| Receive Antenna Gain          | dB      | 41.1                   | 0.0             |
| Receive Antenna Pointing Loss | dB      | -0.1                   | 0.0             |
| Receive Antenna Feed Loss     | dB      | -1.0                   | -1.0            |
| Receiver Input Power          | dBW     | -130.8                 | -131.7          |
| Receiver Command Threshold    | dBW     | -135.0                 | -135.0          |
| Margin                        | dB      | 4.2                    | 3.3             |

**Table C-7 TT&C Telemetry Link Budget**

| Telemetry Downlink         |          | Feeder link<br>Antenna | Omni<br>Antenna |
|----------------------------|----------|------------------------|-----------------|
| Transmit Frequency         | GHz      | 11.7                   | 11.7            |
| Transmit EIRP              | dBW      | 7.9                    | 7.8             |
| Elevation Angle            | degrees  | 10.0                   | 10.0            |
| Free Space Path Loss       | dB       | -201.7                 | -201.7          |
| Atmospheric Loss           | dB       | -0.6                   | -0.6            |
| Rain Loss                  | dB       | -5.0                   | -5.0            |
| Receiver Losses            | dB       | -1.2                   | -1.2            |
| Receive G/T                | dB/K     | 26.4                   | 26.4            |
| Bandwidth                  | dB-Hz    | 42.0                   | 42.0            |
| Boltzman's Constant        | dBW/Hz-K | -228.6                 | -228.6          |
| Downlink C/N (Thermal)     | dB       | 12.4                   | 12.3            |
| Subcarrier Modulation Loss | dB       | -5.0                   | -5.0            |
| Data Rate                  | dB-b/s   | 39.0                   | 39.0            |
| Total Eb/No                | dB       | 10.4                   | 10.3            |
| Required Eb/No             | dB       | 7.1                    | 7.1             |
| Margin                     | dB       | 3.3                    | 3.2             |



**Table C-8 Beacon Link Budget**

| Beacon Link                 |           | NADIR       |             | EOC         |             |
|-----------------------------|-----------|-------------|-------------|-------------|-------------|
|                             |           | Clear       | rain        | clear       | rain        |
| Transmit Frequency          | GHz       | 11.87       | 11.87       | 11.87       | 11.87       |
| Transmitter Power           | Watts     | 0.5         | 0.5         | 0.5         | 0.5         |
| Transmit Antenna Gain       | dB        | 7.6         | 7.6         | 15.3        | 15.3        |
| HPA/Antenna Line Losses     | dB        | -1.0        | -1.0        | -1.0        | -1.0        |
| Transmit EIRP               | dBW       | 3.6         | 3.6         | 11.3        | 11.3        |
| Elevation Angle             | degrees   | 90.0        | 90.0        | 30.0        | 30.0        |
| Path Loss (Clear Sky)       | dB        | -200.0      | -200.0      | -201.1      | -201.1      |
| Atmospheric Loss            | dB        | -0.1        | -0.1        | -0.2        | -0.2        |
| Rain Loss                   | dB        | 0.0         | -1.3        | 0.0         | -2.5        |
| Received Isotropic Power    | dBW       | -196.6      | -197.8      | -190.0      | -192.5      |
| Receive Antenna Gain        | dB        | 36.2        | 36.2        | 31.9        | 31.9        |
| Receiver Losses             | dB        | -0.5        | -0.5        | -0.5        | -0.5        |
| Received Power              | dBW       | -160.9      | -162.1      | -158.6      | -161.1      |
| Data Rate                   | dB-Hz     | 30.0        | 30.0        | 30.0        | 30.0        |
| Eb                          | dBW       | -190.9      | -192.1      | -188.6      | -191.1      |
| System Noise Temperature    | K         | 231.0       | 290.9       | 237.1       | 339.2       |
| No                          | dBW/Hz    | -205.0      | -204.0      | -204.9      | -203.3      |
| Eb/No                       | dB        | 14.1        | 11.8        | 16.2        | 12.2        |
| Eb/No (Intra-System)        | dB        | 19.0        | 17.8        | 21.3        | 18.8        |
| Eb/No (GSO Networks)        | dB        | 23.4        | 22.2        | 25.7        | 23.2        |
| Eb/No (Other NGSO Networks) | dB        | 23.0        | 21.8        | 25.3        | 22.8        |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>12.1</b> | <b>10.2</b> | <b>14.3</b> | <b>10.8</b> |
| <b>Required Eb/No</b>       | <b>dB</b> | <b>5.8</b>  | <b>5.8</b>  | <b>5.8</b>  | <b>5.8</b>  |
| <b>Margin</b>               | <b>dB</b> | <b>6.4</b>  | <b>4.5</b>  | <b>8.6</b>  | <b>5.0</b>  |

**Table C-9 BDS Forward Feeder Link Budget**

| Forward Feeder-Link         |           | Clear       | Rain-up     | Rain-down   | Rain-both   |
|-----------------------------|-----------|-------------|-------------|-------------|-------------|
| <b>Uplink</b>               |           |             |             |             |             |
| Transmit Frequency          | GHz       | 12.9        | 12.9        | 12.9        | 12.9        |
| Transmit Power              | dB W      | 0.5         | 5.0         | 0.5         | 5.0         |
| Antenna Gain                | dB        | 53.5        | 53.5        | 53.5        | 53.5        |
| Transmit Losses             | dB        | -1.1        | -1.1        | -1.1        | -1.1        |
| Transmit EIRP               | dBW       | 49.4        | 59.4        | 49.4        | 59.4        |
| Elevation Angle             | °         | 10.0        | 10.0        | 10.0        | 10.0        |
| Path Loss                   | dB        | -202.5      | -202.5      | -202.5      | -202.5      |
| Atmospheric Loss            | dB        | -0.7        | -0.7        | -0.7        | -0.7        |
| Rain Loss (99.9%)           | dB        | 0.0         | -8.4        | 0.0         | -8.4        |
| Receive Antenna Gain        | dB        | 40.4        | 40.4        | 40.4        | 40.4        |
| Receive System Noise Temp   | k         | 450.6       | 450.6       | 450.6       | 450.6       |
| Receive Losses              | dB        | -0.5        | -0.5        | -0.5        | -0.5        |
| Receiver Input Power        | dB W      | -114.0      | -112.3      | -114.0      | -112.3      |
| Satellite G/T               | dB/K      | 12.9        | 12.9        | 12.9        | 12.9        |
| Noise Bandwidth             | dB-Hz     | 73.8        | 73.8        | 73.8        | 73.8        |
| C/N (Thermal)               | dB        | 14.3        | 15.9        | 14.3        | 15.9        |
| Eb/No (Thermal)             | dB        | 14.3        | 15.9        | 14.3        | 15.9        |
| Eb/No (Intra-System)        | dB        | 20.2        | 15.5        | 20.2        | 15.5        |
| Eb/No (GSO Networks)        | dB        | 21.0        | 22.6        | 21.0        | 22.6        |
| Eb/No (Other NGSO Networks) | dB        | 18.9        | 20.5        | 18.9        | 20.5        |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>11.7</b> | <b>11.7</b> | <b>11.7</b> | <b>11.7</b> |
| <b>Required Eb/(No+Io)</b>  | <b>dB</b> | <b>9.8</b>  | <b>9.8</b>  | <b>9.8</b>  | <b>9.8</b>  |
| <b>Margin</b>               | <b>dB</b> | <b>1.9</b>  | <b>1.9</b>  | <b>1.9</b>  | <b>1.9</b>  |

**Table C-10 BDS Forward Service Link Budget**

| Forward Service-Link        |           | Clear      | Rain-up    | Rain-down  | Rain-both  |
|-----------------------------|-----------|------------|------------|------------|------------|
| <b>Downlink</b>             |           |            |            |            |            |
| Transmit Frequency          | GHz       | 12.6       | 12.6       | 12.6       | 12.6       |
| Transmit Power              | Watts     | 1.7        | 1.7        | 1.7        | 1.7        |
| Antenna Gain (Beam EOC)     | dB        | 42.0       | 42.0       | 42.0       | 42.0       |
| Transmit Losses             | dB        | -1.0       | -1.0       | -1.0       | -1.0       |
| Transmit EIRP               | dBW       | 43.3       | 43.3       | 43.3       | 43.3       |
| Elevation Angle (Beam EOC)  | °         | 30.0       | 30.0       | 30.0       | 30.0       |
| Path Loss                   | dB        | -201.6     | -201.6     | -201.6     | -201.6     |
| Atmospheric Loss            | dB        | -0.2       | -0.2       | -0.2       | -0.2       |
| Rain Loss (99.7%)           | dB        | 0.0        | 0.0        | -2.7       | -2.7       |
| Receive Antenna Gain        | dB        | 41.8       | 41.8       | 41.8       | 41.8       |
| Receive Losses              | dB        | -1.0       | -1.0       | -1.0       | -1.0       |
| Receive Power               | dBW       | -117.9     | -117.9     | -120.7     | -120.7     |
| Data Rate                   | dB-Hz     | 73.9       | 73.9       | 73.9       | 73.9       |
| Eb                          | dBW/Hz    | -191.8     | -191.8     | -194.5     | -194.5     |
| Receive System Noise Temp   | k         | 172.8      | 172.8      | 404.6      | 404.6      |
| No                          | dBW/Hz    | -206.2     | -206.2     | -202.5     | -202.5     |
| Eb/No (Downlink)            | dB        | 14.4       | 14.5       | 8.0        | 8.0        |
| Eb/No (Intra-System)        | dB        | 19.9       | 19.9       | 19.9       | 19.9       |
| Eb/No (GSO Networks)        | dB        | 25.3       | 25.4       | 22.5       | 22.6       |
| Eb/No (Other NGSO Networks) | dB        | 15.0       | 15.0       | 15.0       | 15.0       |
| Eb/(No+No) (Downlink)       | dB        | 10.9       | 10.9       | 6.9        | 6.9        |
| <b>Total Eb/(No+No)</b>     | <b>dB</b> | <b>8.3</b> | <b>8.3</b> | <b>5.6</b> | <b>5.6</b> |
| <b>Required Eb/No*</b>      | <b>dB</b> | <b>5.0</b> | <b>5.0</b> | <b>5.0</b> | <b>5.0</b> |
| <b>Margin</b>               | <b>dB</b> | <b>3.3</b> | <b>3.3</b> | <b>0.6</b> | <b>0.6</b> |

\* BER of  $1 \times 10^{-10}$  including implementation loss.

**Table C-11 BDS Return Service Link Budget**  
Return link of 60 Mbps (QPSK)

| Return Service Link         |           | Clear      | Rain-<br>up | Rain-<br>down | Rain-<br>both |
|-----------------------------|-----------|------------|-------------|---------------|---------------|
| <b>Uplink</b>               |           |            |             |               |               |
| Transmit Frequency          | GHz       | 14.3       | 14.3        | 14.3          | 14.3          |
| Transmit Power              | W         | 2.0        | 5.0         | 2.0           | 5.0           |
| Antenna Gain                | dB        | 42.9       | 42.9        | 42.9          | 42.9          |
| Transmit Losses             | dB        | -1.1       | -1.1        | -1.1          | -1.1          |
| Transmit EIRP               | dBW       | 44.8       | 48.8        | 44.8          | 48.8          |
| Elevation Angle             | °         | 30         | 30          | 30            | 30            |
| Path Loss                   | dB        | -202.7     | -202.7      | -202.7        | -202.7        |
| Atmospheric Loss            | dB        | -0.3       | -0.3        | -0.3          | -0.3          |
| Rain Loss (99.7%)           | dB        | 0.0        | -3.7        | 0.0           | -3.7          |
| Receive Antenna Gain        | dB        | 43.4       | 43.4        | 43.4          | 43.4          |
| Receive System Noise Temp   | k         | 452.1      | 452.1       | 452.1         | 452.1         |
| Receive Losses              | dB        | -1.5       | -1.5        | -1.5          | -1.5          |
| Receiver Input Power        | dB W      | -116.3     | -116.0      | -116.3        | -116.0        |
| Satellite G/T               | dB/K      | 15.8       | 15.8        | 15.8          | 15.8          |
| Noise Bandwidth             | dB-Hz     | 77.7       | 77.7        | 77.7          | 77.7          |
| C/N (Thermal)               | dB        | 8.0        | 8.4         | 8.0           | 8.4           |
| Eb/No (Thermal)             | dB        | 8.0        | 8.4         | 8.0           | 8.4           |
| Eb/No (Intra-System)        | dB        | 20.2       | 20.2        | 20.2          | 20.2          |
| Eb/No (GSO Networks)        | dB        | 15.5       | 15.8        | 15.5          | 15.8          |
| Eb/No (Other NGSO Networks) | dB        | 14.5       | 14.8        | 14.5          | 14.8          |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>6.4</b> | <b>6.7</b>  | <b>6.4</b>    | <b>6.7</b>    |
| <b>Required Eb/No+Io)</b>   | <b>dB</b> | <b>6.1</b> | <b>6.1</b>  | <b>6.1</b>    | <b>6.1</b>    |
| <b>Margin</b>               | <b>dB</b> | <b>0.3</b> | <b>0.6</b>  | <b>0.3</b>    | <b>0.6</b>    |

**Table C-12 BDS Return Feeder Link Budget**  
Return link of 60 Mbps (QPSK)

| Return Feeder-Link          |           | Clear      | Rain-up    | Rain-down  | Rain-both  |
|-----------------------------|-----------|------------|------------|------------|------------|
| <b>Downlink</b>             |           |            |            |            |            |
| Transmit Frequency          | GHz       | 11.3       | 11.3       | 11.3       | 11.3       |
| Transmit Power              | Watts     | 15.0       | 15.0       | 15.0       | 15.0       |
| Antenna Gain (Beam EOC)     | dB        | 39.2       | 39.2       | 39.2       | 39.2       |
| Transmit Losses             | dB        | -1.0       | -1.0       | -1.0       | -1.0       |
| Transmit EIRP               | dBW       | 50.0       | 50.0       | 50.0       | 50.0       |
| Elevation Angle (Beam EOC)  | °         | 10.0       | 10.0       | 10.0       | 10.0       |
| Path Loss                   | dB        | -201.4     | -201.4     | -201.4     | -201.4     |
| Atmospheric Loss            | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Rain Loss (99.9%)           | dB        | 0.0        | 0.0        | -6.6       | -6.6       |
| Receive Antenna Gain        | dB        | 52.3       | 52.3       | 52.3       | 52.3       |
| Receive Losses              | dB        | -0.5       | -0.5       | -0.5       | -0.5       |
| Receive Power               | dBW       | -100.6     | -100.5     | -107.2     | -107.2     |
| Data Rate                   | dB-Hz     | 77.8       | 77.8       | 77.8       | 77.8       |
| Eb                          | dBW/Hz    | -178.3     | -178.3     | -185.0     | -185.0     |
| Receive System Noise Temp   | k         | 198.7      | 198.7      | 341.0      | 341.0      |
| No                          | dBW/Hz    | -205.6     | -205.6     | -203.3     | -203.3     |
| Eb/No (Downlink)            | dB        | 27.3       | 27.3       | 18.3       | 18.3       |
| Eb/No (Intra-System)        | dB        | 20.2       | 20.2       | 14.2       | 14.2       |
| Eb/No (GSO Networks)        | dB        | 29.7       | 29.7       | 23.0       | 23.0       |
| Eb/No (Other NGSO Networks) | dB        | 20.0       | 20.0       | 20.0       | 20.0       |
| Eb/(No+Io) (Downlink)       | dB        | 16.5       | 16.5       | 11.6       | 11.7       |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>6.0</b> | <b>6.3</b> | <b>5.2</b> | <b>5.5</b> |
| <b>Required Eb/No</b>       | <b>dB</b> | <b>5.0</b> | <b>5.0</b> | <b>5.0</b> | <b>5.0</b> |
| <b>Margin</b>               | <b>dB</b> | <b>1.0</b> | <b>1.3</b> | <b>0.2</b> | <b>0.5</b> |

\* BER of  $1 \times 10^{-10}$  including implementation loss.

**Table C-13 BDS Return Service Link Budget**  
Return link of 120 Mbps (16QAM)

| Return Service Link         |           | Clear       | Rain-<br>up | Rain-<br>down | Rain-<br>both |
|-----------------------------|-----------|-------------|-------------|---------------|---------------|
| <b>Uplink</b>               |           |             |             |               |               |
| Transmit Frequency          | GHz       | 14.3        | 14.3        | 14.3          | 14.3          |
| Transmit Power              | W         | 25.0        | 50.0        | 25.0          | 50.0          |
| Antenna Gain                | dB        | 42.9        | 42.9        | 42.9          | 42.9          |
| Transmit Losses             | dB        | -1.1        | -1.1        | -1.1          | -1.1          |
| Transmit EIRP               | dBW       | 55.8        | 58.8        | 55.8          | 58.8          |
| Elevation Angle             | °         | 30          | 30          | 30            | 30            |
| Path Loss                   | dB        | -202.7      | -202.7      | -202.7        | -202.7        |
| Atmospheric Loss            | dB        | -0.3        | -0.3        | -0.3          | -0.3          |
| Rain Loss (99.7%)           | dB        | 0.0         | -3.7        | 0.0           | -3.7          |
| Receive Antenna Gain        | dB        | 43.4        | 43.4        | 43.4          | 43.4          |
| Receive System Noise Temp   | k         | 452.1       | 452.1       | 452.1         | 452.1         |
| Receive Losses              | dB        | -1.5        | -1.5        | -1.5          | -1.5          |
| Receiver Input Power        | dB W      | -105.4      | -106.0      | -105.4        | -106.0        |
| Satellite G/T               | dB/K      | 15.8        | 15.8        | 15.8          | 15.8          |
| Noise Bandwidth             | dB-Hz     | 77.7        | 77.7        | 77.7          | 77.7          |
| C/N (Thermal)               | dB        | 19.0        | 18.4        | 19.0          | 18.4          |
| Eb/No (Thermal)             | dB        | 15.9        | 15.2        | 15.9          | 15.2          |
| Eb/No (Intra-System)        | dB        | 20.2        | 20.2        | 20.2          | 20.2          |
| Eb/No (GSO Networks)        | dB        | 23.5        | 22.8        | 23.5          | 22.8          |
| Eb/No (Other NGSO Networks) | dB        | 20.7        | 20.0        | 20.7          | 20.0          |
| <b>Total Eb/(No+Io)</b>     | <b>dB</b> | <b>13.2</b> | <b>12.6</b> | <b>13.2</b>   | <b>13.6</b>   |
| <b>Required Eb/(No+Io)</b>  | <b>dB</b> | <b>12.6</b> | <b>12.6</b> | <b>12.6</b>   | <b>12.6</b>   |
| <b>Margin</b>               | <b>dB</b> | <b>0.6</b>  | <b>0.0</b>  | <b>0.6</b>    | <b>0.0</b>    |

**Table C-14 BDS Return Feeder Link Budget**  
Return link of 120 Mbps (16QAM)

| Return Feeder-Link          |           | Clear       | Rain-up     | Rain-down  | Rain-both  |
|-----------------------------|-----------|-------------|-------------|------------|------------|
| <b>Downlink</b>             |           |             |             |            |            |
| Transmit Frequency          | GHz       | 11.3        | 11.3        | 11.3       | 11.3       |
| Transmit Power              | Watts     | 15.0        | 15.0        | 15.0       | 15.0       |
| Antenna Gain (Beam EOC)     | dB        | 39.2        | 39.2        | 39.2       | 39.2       |
| Transmit Losses             | dB        | -1.0        | -1.0        | -1.0       | -1.0       |
| Transmit EIRP               | dBW       | 50.0        | 50.0        | 50.0       | 50.0       |
| Elevation Angle (Beam EOC)  | °         | 10.0        | 10.0        | 10.0       | 10.0       |
| Path Loss                   | dB        | -201.4      | -201.4      | -201.4     | -201.4     |
| Atmospheric Loss            | dB        | -0.5        | -0.5        | -0.5       | -0.5       |
| Rain Loss (99.9%)           | dB        | 0.0         | 0.0         | -6.6       | -6.6       |
| Receive Antenna Gain        | dB        | 52.3        | 52.3        | 52.3       | 52.3       |
| Receive Losses              | dB        | -0.5        | -0.5        | -0.5       | -0.5       |
| Receive Power               | dBW       | -100.1      | -100.1      | -106.7     | -106.8     |
| Data Rate                   | dB-Hz     | 80.8        | 80.8        | 80.8       | 80.8       |
| Eb                          | dBW/Hz    | -180.9      | -180.9      | -187.5     | -187.5     |
| Receive System Noise Temp   | k         | 198.7       | 198.7       | 341.0      | 341.0      |
| No                          | dBW/Hz    | -205.6      | -205.6      | -203.3     | -203.3     |
| Eb/No (Downlink)            | dB        | 24.7        | 24.7        | 15.7       | 15.7       |
| Eb/No (Intra-System)        | dB        | 20.2        | 20.2        | 14.1       | 14.1       |
| Eb/No (GSO Networks)        | dB        | 27.1        | 27.1        | 20.5       | 20.5       |
| Eb/No (Other NGSO Networks) | dB        | 20.0        | 20.0        | 20.0       | 20.0       |
| Eb/(No+No) (Downlink)       | dB        | 16.1        | 16.1        | 10.7       | 10.7       |
| <b>Total Eb/(No+No)</b>     | <b>dB</b> | <b>11.4</b> | <b>11.0</b> | <b>8.8</b> | <b>8.6</b> |
| <b>Required Eb/No</b>       | <b>dB</b> | <b>8.6</b>  | <b>8.6</b>  | <b>8.6</b> | <b>8.6</b> |
| <b>Margin</b>               | <b>dB</b> | <b>2.8</b>  | <b>2.4</b>  | <b>0.2</b> | <b>0.0</b> |

\* BER of  $1 \times 10^{-10}$  including implementation loss.