

Financial Qualifications

9. FINANCIAL QUALIFICATIONS

Hughes Communications Inc. is an indirect wholly-owned subsidiary of Hughes Electronics Corporation (HE), a large aerospace, electronics manufacturing, and satellite communications company. HE, in turn, is an affiliate of General Motors Corporation (GM). As demonstrated in Appendix D, containing the consolidated financial statements of HE, HE has sufficient current assets to fund the construction, launch, and first-year operating costs of the Expressway™ satellite system.

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10. ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's Rules, that I have either prepared or reviewed the engineering information submitted in this application, and that it is complete and accurate to the best of my knowledge and belief.

By:



Daniel P. Sullivan, Ph.D.

Vice President, Engineering

Hughes Communications, Inc.

September 22, 1997

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Certifications

11. WAIVER AND CERTIFICATIONS

In accordance with Section 304 of the Communications Act of 1934, as amended, 47 U.S.C. 304, HCI hereby waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise.

HCI certifies that neither the Applicant nor any of its shareholders, nor any of its officers or directors, nor any party to this application is subject to a denial of Federal benefits pursuant to authority granted in Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 862.

The undersigned certifies individually and for HCI that all of the statements made in this Application are true, complete, and accurate to the best of his information, belief and knowledge, and are made in good faith.

Respectfully submitted,

Hughes Communications, Inc.

By:



Jerald F. Farrell

President

September 22, 1997

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Conclusion

12. CONCLUSION

For the reasons set forth in this Application, HCI respectfully requests that the Commission promptly grants this application to enable HCI to bring to the public the significant benefits described above at the earliest possible time.

Respectfully submitted,

Hughes Communications, Inc.

By:



Jerald F. Farrell

President

September 22, 1997

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Appendix A

Transmission Characteristics

APPENDIX A: TRANSMISSION CHARACTERISTICS

Expressway™ link budget information is provided in Tables A-1a through A-5. The RF communication links include the following: V-band, Ku-band area coverage, Ku-band 6° coverage, satellite telemetry, and satellite command. A user terminal uses a 2.5 meter antenna. The Satellite Control Facilities (SCF) use 7-meter antennas for telemetry and command.

In all cases, link budget calculations place a desired terminal at the satellite antenna beam edge. Rain attenuation effects are estimated based on the Crane Global rain model as described in the NASA Reference publication 1082(04) 1989, *Propagation Effects Handbook for Satellite Systems Design*. Atmospheric attenuation is estimated based on the ITU's Recommendation 676-2. Cloud attenuation is estimated based on the ITU's Recommendation 840-1 for an average cloud thickness of 2 km. The representative link budgets show calculations for a satellite placed at an orbital position of 101° W. The elevation angle to the satellite was determined for each of the cities shown. All cases show a positive margin at the indicated average link availability values.

Tables A-1a and A-1b contain the representative wideband data service links operating at V-band. Table A-1a shows a New York uplink to Boston downlink. Table A-1b shows a Los Angeles uplink to a New York downlink. In both cases, a user terminal uses a 2.5 meter antenna and a 30 W HPA. This results in uplink EIRPs of 71.3 dBW and 73.8 dBW in clear and rain conditions, respectively. The satellite minimum EIRP per each 155 Mbps carrier is 56 dBW. The link margin of

0.0 dB for clear-sky uplink and rainy downlink conditions indicates that the specified link availability objective can be met; the same is true for all link budgets presented in this Appendix.

Tables A-2a and A-2b contain link budgets for the Ku-band data service for the northern hemisphere using $1^{\circ} \times 3^{\circ}$ elliptical beams. A New York uplink to Boston downlink is shown in Table A-2a as a representative case of higher link performance for a low rain rate region. A Miami uplink to Boston downlink is shown in Table A-2b as a representative case of a link in a challenging rain area.

The satellite minimum EIRP is 47.0 dBW for a single 155 Mbps carrier. An uplink terminal uses a 2.5 meter antenna with a 100 W HPA. This corresponds to an EIRP of 67.5 dBW for the clear sky condition and 68.5 dBW for the rain condition. The resulting link average availability depends on the location of interest (typically better than 99.70%).

Tables A-3a through A-3d contain link budgets for the Ku band data service for a 6° hemispherical beam from a 101° W orbital position. Tables A-3a and A-3b show Boston to Bogota, Colombia links as representative cases in a challenging rain area. Tables A-3c and A-3d show Los Angeles to Bogota links for higher performance in a low rain rate region. For the 6° hemispherical beam, the satellite minimum EIRP is 45.3 dBW. An uplink terminal uses a 2.5 meter antenna with a 200 W HPA. This corresponds to an EIRP of 69.5 dBW for the clear sky condition and 71.5 dBW for the rain condition.

Tables A-4 and A-5 contain the information regarding the satellite telemetry and command links. Dry geographical regions are selected along with favorable

elevation angles for satellite operational control facilities to provide high reliability TT&C links.

Table A-1a V-Band - New York U/L to Boston D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|-----------------------------------|----------|-------|----------|----------------------------|--------|--------|--------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | New York | | | | Boston | | |
| Site Elevation Angle | 35.4 | | deg | | | | deg |
| Site Altitude (ASL) | 0.0 | | km | | | | km |
| Frequency | 48.7 | | GHz | | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 155 | | Mbps | | | | Mbps |
| Station Transmitter Power | 30.0 | | W | | | | W |
| Transmitter Pwr (dBW) | 14.8 | | dBW | | | | dBW |
| Uplink Power Back-off | 3 | | dB | | | | dB |
| # of Amplified Carriers | 1 | | | | | | |
| Station Transmitter Losses | 0.5 | | dB | | | | |
| Station Antenna Diameter | 2.50 | | m | | | | |
| Station Peak Antenna Gain | 59.5 | | dBi | | | | |
| Operating EIRP per carrier | | 71.3 | 73.8 | dBW | | 56.0 | 56.0 |
| Space Loss | | 217.8 | 217.8 | dB | | 216.4 | 216.4 |
| Atm. (Gas + Cloud) Att. | | 5.1 | 5.4 | dB | | 3.1 | 3.3 |
| Rain Attenuation | | | 5.2 | dB | | | 2.6 |
| Pointing and Pol. Loss | | 0.5 | 0.5 | dB | | 0.5 | 0.5 |
| Sat. Antenna Gain | 49.0 | | dBi | | | | dBi |
| System Noise Temp | 649.2 | | 'K | | | | 'K |
| System Noise Temp | 28.1 | | dBK | | | | dBK |
| Satellite G/T | 20.4 | | dB/K | | | 30.8 | 29.9 |
| Boltzmann's Constant | -228.6 | | dBW/K-Hz | | | -228.6 | -228.6 |
| Noise BW | 83.0 | | dBHz | | | 83.0 | 83.0 |
| C/N (Thermal) | 13.8 | | dB | | | 12.4 | 8.7 |
| Uplink Conditions | | | | clear | rain | clear | |
| Downlink Conditions | | | | clear | clear | rain | |
| UL C/(No) (dB/Hz) | | | | 96.8 | 93.9 | 96.8 | dB/Hz |
| UL C/(Ilo) (dB/Hz) | | | | 97.0 | 97.0 | 97.0 | dB/Hz |
| UL C/(No+lo) (dB/Hz) | | | | 93.9 | 92.1 | 93.9 | dB/Hz |
| D/L C/(No) (dB/Hz) | | | | 95.4 | 95.4 | 91.7 | dB/Hz |
| D/L C/(Ilo) (dB/Hz) | | | | 97.2 | 97.2 | 97.2 | dB/Hz |
| D/L C/(No+lo) (dB/Hz) | | | | 93.2 | 93.2 | 90.6 | dB/Hz |
| Total C/(No+lo) (dB/Hz) | | | | 90.5 | 89.6 | 88.9 | dB/Hz |
| Required C/N (dB/Hz) | | | | 88.9 | 88.9 | 88.9 | dB/Hz |
| Margin (dB) | | | | 1.6 | 0.7 | 0.0 | dB |

Table A-1b V-Band - Los Angeles U/L to New York D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|-----------------------------------|-------------|-------|----------|----------------------------|----------|--------|--------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | Los Angeles | | | | New York | | |
| Site Elevation Angle | 46.5 | | deg | | | | deg |
| Site Altitude (ASL) | 0.1 | | km | | | | km |
| Frequency | 48.7 | | GHz | | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 155 | | Mbps | | | | Mbps |
| Station Transmitter Power | 30.0 | | W | | | | W |
| Transmitter Pwr (dBW) | 14.8 | | dBW | | | | dBW |
| Uplink Power Back-off | 3 | | dB | | | | dB |
| # of Amplified Carriers | 1 | | | | | | |
| Station Transmitter Losses | 0.5 | | dB | | | | |
| Station Antenna Diameter | 2.50 | | m | | | | |
| Station Peak Antenna Gain | 59.5 | | dBi | | | | |
| Operating EIRP per carrier | | 71.3 | 73.8 | dBW | | 56.0 | 56.0 |
| Space Loss | | 217.6 | 217.6 | dB | | 216.3 | 216.3 |
| Atm. (Gas + Cloud) Att. | | 3.8 | 3.9 | dB | | 2.9 | 3.0 |
| Rain Attenuation | | | 6.6 | dB | | | 3.2 |
| Pointing and Pol. Loss | | 0.5 | 0.5 | dB | | 0.5 | 0.5 |
| Sat. Antenna Gain | 49.0 | | dBi | | | | dBi |
| System Noise Temp | 649.2 | | 'K | | | | 'K |
| System Noise Temp | 28.1 | | dBK | | | | dBK |
| Satellite G/T | 20.4 | | dB/K | | | 30.9 | 29.8 |
| Boltzmann's Constant | -228.6 | | dBW/K-Hz | | | -228.6 | -228.6 |
| Noise BW | 83.0 | | dBHz | | | 83.0 | 83.0 |
| C/N (Thermal) | 15.3 | | dB | | | 12.8 | 8.3 |
| Uplink Conditions | | | | clear | rain | clear | |
| Downlink Conditions | | | | clear | clear | rain | |
| UL C/(No) (dB/Hz) | | | | 98.3 | 94.2 | 98.3 | dB/Hz |
| UL C/(Ilo) (dB/Hz) | | | | 97.0 | 97.0 | 97.0 | dB/Hz |
| UL C/(No+lo) (dB/Hz) | | | | 94.6 | 92.3 | 94.6 | dB/Hz |
| D/L C/(No) (dB/Hz) | | | | 95.8 | 95.8 | 91.3 | dB/Hz |
| D/L C/(Ilo) (dB/Hz) | | | | 97.2 | 97.2 | 97.2 | dB/Hz |
| D/L C/(No+lo) (dB/Hz) | | | | 93.4 | 93.4 | 90.3 | dB/Hz |
| Total C/(No+lo) (dB/Hz) | | | | 91.0 | 89.8 | 88.9 | dB/Hz |
| Required C/N (dB/Hz) | | | | 88.9 | 88.9 | 88.9 | dB/Hz |
| Margin (dB) | | | | 2.0 | 0.9 | 0.0 | dB |

Table A-2a Ku-Band - New York U/L to Boston D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|-----------------------------------|----------|------|----------|----------------------------|-------------|------|-------------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | New York | I | | | Boston | | |
| Site Elevation Angle | 35.4 | | deg | 32.5 | | | deg |
| Site Altitude (ASL) | 0.0 | | km | 0.0 | | | km |
| Frequency | 13.0 | | GHz | 11.0 | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 155 | | Mbps | 155 | | | Mbps |
| Station Transmitter Power | 100.0 | | W | 2.5 | | | W |
| Transmitter Pwr (dBW) | 20.0 | | dBW | 14.0 | | | dBW |
| Uplink Power Back-off | 1 | | dB | 0 | | | dB |
| # of Amplified Carriers | 1 | | | | | | |
| Station Transmitter Losses | 0.3 | | | | | | |
| Station Antenna Diameter | 2.50 | | m | | | | |
| Station Peak Antenna Gain | 48.8 | | dBi | | | | |
| Operating EIRP per carrier | 67.5 | | dBW | | | | |
| Space Loss | 206.3 | | dB | | | | |
| Atm. (Gas + Cloud) Att. | 0.3 | | dB | | | | |
| Rain Attenuation | | | | | | | |
| Pointing and Pol. Loss | | 0.4 | dB | | | | |
| Sat. Antenna Gain | 33.5 | | dBi | | | | |
| System Noise Temp | 365.1 | | 'K | | | | |
| System Noise Temp | 25.6 | | dBK | | | | |
| Satellite G/T | 7.4 | | dB/K | | | | |
| Boltzmann's Constant | -228.6 | | dBW/K-Hz | | | | |
| Noise BW | 83.0 | | dBHz | | | | |
| C/N (Thermal) | 13.3 | | dB | | | | |
| Total U/L C/I | 14.1 | | | | | | |
| UL C/I(Io) | | 97.1 | | | 93.7 | | 96.3 |
| Thermal U/L C/(No) | | 96.3 | | | 97.1 | | 97.1 |
| Total D/L C/I | 10.1 | | | | 93.7 | | 93.7 |
| D/L C/I(Io) | | 93.1 | | | 92.1 | | 94.2 |
| Thermal D/L C/(No) | | 97.2 | | | 97.2 | | 94.2 |
| Required Eb/No | 6.5 | | dB | | | | |
| Effective Data Rate | 174 | | Mbps | | | | |
| Data Rate (dB) | 82.4 | | dB (bps) | | | | |
| Required C/(No+Io) | | 88.9 | | | 88.9 | | 88.9 |
| | | | | | Margin (dB) | | Margin (dB) |
| | | | | | 0.7 | 0.0 | 0.0 |
| | | | | | | | |

Table A-2b Ku-Band - Miami U/L to Boston D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|-----------------------------------|--------|------|----------|----------------------------|-------------|------|-------------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | Miami | I | | | Boston | | |
| Site Elevation Angle | 52.0 | | deg | 32.5 | | | deg |
| Site Altitude (ASL) | 0.0 | | km | 0.0 | | | km |
| Frequency | 13.0 | | GHz | 11.0 | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 155 | | Mbps | 155 | | | Mbps |
| Station Transmitter Power | 100.0 | | W | 2.5 | | | W |
| Transmitter Pwr (dBW) | 20.0 | | dBW | 14.0 | | | dBW |
| Uplink Power Back-off | 1 | | dB | 0 | | | dB |
| # of Amplified Carriers | 1 | | | | | | |
| Station Transmitter Losses | 0.3 | | | | | | |
| Station Antenna Diameter | 2.50 | | m | | | | |
| Station Peak Antenna Gain | 48.8 | | dBi | | | | |
| Operating EIRP per carrier | 67.5 | | dBW | | | | |
| Space Loss | 206.1 | | dB | | | | |
| Atm. (Gas + Cloud) Att. | 0.3 | | dB | | | | |
| Rain Attenuation | | | | | | | |
| Pointing and Pol. Loss | | 0.4 | dB | | | | |
| Sat. Antenna Gain | 33.5 | | dBi | | | | |
| System Noise Temp | 365.1 | | 'K | | | | |
| System Noise Temp | 25.6 | | dBK | | | | |
| Satellite G/T | 7.4 | | dB/K | | | | |
| Boltzmann's Constant | -228.6 | | dBW/K-Hz | | | | |
| Noise BW | 83.0 | | dBHz | | | | |
| C/N (Thermal) | 13.7 | | dB | | | | |
| Total U/L C/I | 14.1 | | | | | | |
| UL C/I(Io) | | 97.1 | | | 93.8 | | 96.7 |
| Thermal U/L C/(No) | | 96.7 | | | 97.1 | | 97.1 |
| Total D/L C/I | 10.1 | | | | 93.9 | | 93.9 |
| D/L C/I(Io) | | 93.1 | | | 92.1 | | 93.9 |
| Thermal D/L C/(No) | | 97.2 | | | 97.2 | | 94.2 |
| Required Eb/No | 6.5 | | dB | | | | |
| Effective Data Rate | 174 | | Mbps | | | | |
| Data Rate (dB) | 82.4 | | dB (bps) | | | | |
| Required C/(No+Io) | | 88.9 | | | 88.9 | | 88.9 |
| | | | | | Margin (dB) | | Margin (dB) |
| | | | | | 0.7 | 0.0 | 0.0 |
| | | | | | | | |

Table A-3a Ku-Band 6° - Boston U/L to Bogota D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|----------------------------------|--------|--------|----------|--------------------------------|--------|------|----------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | Boston | | | Bogota | | | |
| Site Elevation Angle | 32.5 | | deg | 58.2 | | | deg |
| Site Altitude (ASL) | 0.0 | | km | 0.0 | | | km |
| Frequency | 13.0 | | GHz | 11.0 | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 100 | | Mbps | 100 | | | Mbps |
| Station Transmitter Power | 100.0 | | W | 100 | | | W |
| Transmitter Pwr (dBW) | 20.0 | | dBW | Sat. Transmit Power | 20.0 | | dBW |
| Uplink Power Back-off | 2 | | dB | Sat. HPA Backoff | 0 | | dB |
| # of Amplified Carriers | 1 | | | Transmitter Total losses | 0.5 | | |
| Station Transmitter Losses | 0.3 | | dB | Sat. Min. Ant. Gain | 25.8 | | dB |
| Station Antenna Diameter | 2.50 | | m | Total EIRP of DL | 45.3 | | dBW |
| Station Peak Antenna Gain | 48.8 | | dBi | Operating EIRP/carrier | 45.3 | | dBW |
| Operating EIRP per carrier | | 66.5 | dBW | Space Loss | 204.5 | | dB |
| Space Loss | | 206.4 | dB | Atm. (Gas + Cloud) Attenuation | 0.2 | | dB |
| Atm. (Gas + Cloud) Att. | | 0.4 | dB | Rain Attenuation | | 2.3 | dB |
| Rain Attenuation | | 0.4 | dB | User Ant. Pointing Losses | 0.4 | | dB |
| Pointing and Pol. Loss | | 5.8 | dB | Revr. Antenna Gain | 47.3 | | dBi |
| Sat. Antenna Gain | 33.5 | | dBi | System Noise Temp | 89.6 | | 'K |
| System Noise Temp | 365.1 | | K | System Noise Temp | 19.5 | | dBK |
| System Noise Temp | 25.6 | | dBK | Station G/T | 27.5 | | dBK |
| Satellite G/T | | 7.4 | dB/K | Boltzmann's Constant | -228.6 | | dBW/K-Hz |
| Boltzmann's Constant | | -228.6 | dBW/K-Hz | Noise BW | 81.1 | | dBHz |
| Noise BW | 81.1 | | dBHz | C/N (Thermal) | 15.2 | | dB |
| C/N (Thermal) | | 14.2 | dB | | | | |
| Total U/L C/I | 14.1 | | | Uplink Conditions | clear | rain | clear |
| U/L C/(Io) | | 95.2 | dB/Hz | Downlink Conditions | clear | rain | clear |
| Thermal U/L C/(No) | | 95.3 | dB/Hz | U/L C/(No) (dB/Hz) | 95.3 | 91.4 | 95.3 |
| Total D/L C/I | 11.6 | | | U/L C/(Io) (dB/Hz) | 95.2 | 95.2 | 95.2 |
| D/L C/(Io) | | 92.7 | dB/Hz | U/L C/(No+Io) (dB/Hz) | 92.2 | 89.9 | 92.2 |
| Thermal D/L C/(No) | | 96.3 | dB/Hz | D/L C/(No) (dB/Hz) | 96.3 | 96.3 | 90.6 |
| Required Eb/No | 6.5 | | dB | D/L C/(Io) (dB/Hz) | 92.7 | 92.7 | 92.7 |
| Effective Data Rate | 112 | | Mbps | D/L C/(No+Io) (dB/Hz) | 91.1 | 91.1 | 88.5 |
| Data Rate (dB) | 80.5 | | dBps | Total C/(No+Io) (dB/Hz) | 88.6 | 87.5 | 87.0 |
| Required C/(No+Io) | | 87.0 | dB/Hz | Required C/No (dB/Hz) | 87.0 | 87.0 | 87.0 |
| | | | | Margin (dB) | 1.6 | 0.5 | 0.0 |

Table A-3b Ku-Band 6° - Bogota U/L to Boston D/L

| SUMMARY of Uplink Budget | | | | SUMMARY of Downlink Budget | | | |
|----------------------------------|--------|--------|----------|--------------------------------|--------|------|----------|
| | Clear | Rain | Units | | Clear | Rain | Units |
| Terminal Location: | Bogota | | | Boston | | | |
| Site Elevation Angle | 58.2 | | deg | 32.5 | | | deg |
| Site Altitude (ASL) | 0.0 | | km | 0.0 | | | km |
| Frequency | 13.0 | | GHz | 11.0 | | | GHz |
| Link Availability | | | % | | | | % |
| Application Data Rate | 100 | | Mbps | 100 | | | Mbps |
| Station Transmitter Power | 200.0 | | W | 25 | | | W |
| Transmitter Pwr (dBW) | 23.0 | | dBW | Sat. Transmit Power | 14.0 | | dBW |
| Uplink Power Back-off | 2 | | dB | Sat. HPA Backoff | 0 | | dB |
| # of Amplified Carriers | 1 | | | Transmitter Total losses | 0.5 | | |
| Station Transmitter Losses | 0.3 | | dB | Sat. Min. Ant. Gain | 33.5 | | dB |
| Station Antenna Diameter | 2.50 | | m | Total EIRP of DL | 47.0 | | dBW |
| Station Peak Antenna Gain | 48.8 | | dBi | Operating EIRP/carrier | 47.0 | | dBW |
| Operating EIRP per carrier | | 69.5 | dBW | Space Loss | 205.0 | | dB |
| Space Loss | | 206.0 | dB | Atm. (Gas + Cloud) Attenuation | 0.3 | | dB |
| Atm. (Gas + Cloud) Att. | | 0.3 | dB | Rain Attenuation | | 1.2 | dB |
| Rain Attenuation | | 3.1 | dB | User Ant. Pointing Losses | 0.4 | | dB |
| Pointing and Pol. Loss | | 0.4 | dB | Revr. Antenna Gain | 47.3 | | dBi |
| Sat. Antenna Gain | 26.2 | | dBi | System Noise Temp | 94.5 | | 'K |
| System Noise Temp | 365.1 | | K | System Noise Temp | 19.8 | | dBK |
| System Noise Temp | 25.6 | | dBK | Station G/T | 27.3 | | dBK |
| Satellite G/T | | 0.1 | dB/K | Boltzmann's Constant | -228.6 | | dBW/K-Hz |
| Boltzmann's Constant | | -228.6 | dBW/K-Hz | Noise BW | 81.1 | | dBHz |
| Noise BW | 81.1 | | dBHz | C/N (Thermal) | 16.1 | | dB |
| C/N (Thermal) | | 10.4 | dB | | | | |
| Total U/L C/I | 14.1 | | | Uplink Conditions | clear | rain | clear |
| U/L C/(Io) | | 95.2 | dB/Hz | Downlink Conditions | clear | rain | clear |
| Thermal U/L C/(No) | | 91.5 | dB/Hz | U/L C/(No) (dB/Hz) | 91.5 | 90.4 | 91.5 |
| Total D/L C/I | 11.6 | | | U/L C/(Io) (dB/Hz) | 95.2 | 95.2 | 95.2 |
| D/L C/(Io) | | 92.7 | dB/Hz | U/L C/(No+Io) (dB/Hz) | 90.0 | 89.1 | 90.0 |
| Thermal D/L C/(No) | | 97.2 | dB/Hz | D/L C/(No) (dB/Hz) | 97.2 | 97.2 | 93.8 |
| Required Eb/No | 6.5 | | dB | D/L C/(Io) (dB/Hz) | 92.7 | 92.7 | 92.7 |
| Effective Data Rate | 112 | | Mbps | D/L C/(No+Io) (dB/Hz) | 91.4 | 91.4 | 90.2 |
| Data Rate (dB) | 80.5 | | dBps | Total C/(No+Io) (dB/Hz) | 87.6 | 87.1 | 87.1 |
| Required C/(No+Io) | | 87.0 | dB/Hz | Required C/No (dB/Hz) | 87.0 | 87.0 | 87.0 |
| | | | | Margin (dB) | 0.6 | 0.1 | 0.1 |

Table A-3c Ku-Band 6° - Los Angeles U/L to Bogota D/L

| SUMMARY of Uplink Budget | | | | | SUMMARY of Downlink Budget | | | | |
|----------------------------|--------------------|--------|----------|--|--------------------------------|--------|----------|-------|-------|
| | Clear | Rain | Units | | Clear | Rain | Units | | |
| Terminal Location: | Los Angeles | | | | Bogota | | | | |
| Site Elevation Angle | 46.5 | | deg | | 58.2 | | deg | | |
| Site Altitude (ASL) | 0.1 | | km | | 0.0 | | km | | |
| Frequency | 13.0 | | GHz | | 11.0 | | GHz | | |
| Link Availability | | | % | | | | % | | |
| Application Data Rate | 155 | | Mbps | | 155 | | Mbps | | |
| Station Transmitter Power | 100.0 | | W | | 100 | | W | | |
| Transmitter Pwr (dBW) | 20.0 | | dBW | | 20.0 | | dBW | | |
| Uplink Power Back-off | 1 | | dB | | 0 | | dB | | |
| # of Amplified Carriers | 1 | | | | 1 | | | | |
| Station Transmitter Losses | 0.3 | | dB | | Transmitter Total losses | 0.5 | dB | | |
| Station Antenna Diameter | 2.50 | | m | | Sat. Min. Ant. Gain | 25.8 | dBi | | |
| Station Peak Antenna Gain | 48.8 | | dBi | | Total EIRP of D/L | 45.3 | dBW | | |
| Operating EIRP per carrier | | | dBW | | Operating EIRP/carrier | 45.3 | dBW | | |
| Space Loss | 206.2 | 206.2 | dB | | Space Loss | 204.5 | dB | | |
| Atm. (Gas + Cloud) Att. | 0.2 | 0.3 | dB | | Atm. (Gas + Cloud) Attenuation | 0.2 | dB | | |
| Rain Attenuation | | 0.4 | dB | | Rain Attenuation | | dB | | |
| Pointing and Pol. Loss | | 3.0 | dB | | User Ant. Pointing Losses | 1.3 | dB | | |
| Sat. Antenna Gain | 33.5 | 33.5 | 'K | | Recvr. Antenna Gain | 47.3 | dBi | | |
| System Noise Temp | 365.1 | 365.1 | dBK | | System Noise Temp | 89.6 | 'K | | |
| System Noise Temp | 25.6 | 25.6 | dB/K | | System Noise Temp | 19.5 | dBK | | |
| Satellite G/T | 7.4 | 7.4 | dBK | | Station G/T | 27.5 | dBK | | |
| Boltzmann's Constant | -228.6 | -228.6 | dBW/K-Hz | | Boltzmann's Constant | -228.6 | dBW/K-Hz | | |
| Noise BW | 83.0 | 83.0 | dBHz | | Noise BW | 83.0 | dBHz | | |
| C/N (Thermal) | 13.6 | 11.6 | dB | | C/N (Thermal) | 9.7 | dB | | |
| Total U/L C/I | 14.1 | | dB | | Uplink Conditions | clear | rain | clear | |
| U/L C/(Io) | | 97.1 | dB/Hz | | Downlink Conditions | clear | rain | clear | |
| Thermal U/L C/(No) | | 96.6 | dB/Hz | | U/L C/(No) (dB/Hz) | 96.6 | dB/Hz | 96.6 | dB/Hz |
| Total D/L C/I | 11.6 | | dB | | U/L C/(Io) (dB/Hz) | 97.1 | dB/Hz | 97.1 | dB/Hz |
| D/L C/(Io) | | 94.6 | dB/Hz | | U/L C/(No+Io) (dB/Hz) | 93.9 | dB/Hz | 93.9 | dB/Hz |
| Thermal D/L C/(No) | | 95.3 | dB/Hz | | D/L C/(No) (dB/Hz) | 96.3 | dB/Hz | 92.7 | dB/Hz |
| Required Eb/No | 6.5 | | dB | | D/L C/(Io) (dB/Hz) | 94.6 | dB/Hz | 94.6 | dB/Hz |
| Effective Data Rate | 174 | | Mbps | | D/L C/(No+Io) (dB/Hz) | 92.3 | dB/Hz | 90.5 | dB/Hz |
| Data Rate (dB) | 82.4 | | dB (bps) | | Total C/(No+Io) (dB/Hz) | 90.0 | dB/Hz | 88.9 | dB/Hz |
| Required C/(No+Io) | | 88.9 | dB/Hz | | Required C/No (dB/Hz) | 88.9 | dB/Hz | 88.9 | dB/Hz |
| Total Margin (dB) | | | | | Margin (dB) | 1.1 | dB | 0.6 | dB |
| Margin (dB) | | | | | Margin (dB) | 0.0 | dB | 0.0 | dB |

Table A-3d Ku-Band 6° - Bogota U/L to Los Angeles D/L

| SUMMARY of Uplink Budget | | | | | SUMMARY of Downlink Budget | | | | |
|----------------------------|---------------|--------|----------|--|--------------------------------|--------|----------|-------|-------|
| | Clear | Rain | Units | | Clear | Rain | Units | | |
| Terminal Location: | Bogota | | | | Los Angeles | | | | |
| Site Elevation Angle | 58.2 | | deg | | 46.5 | | deg | | |
| Site Altitude (ASL) | 0.0 | | km | | 0.1 | | km | | |
| Frequency | 13.0 | | GHz | | 11.0 | | GHz | | |
| Link Availability | | | % | | | | % | | |
| Application Data Rate | 100 | | Mbps | | 100 | | Mbps | | |
| Station Transmitter Power | 200.0 | | W | | 25 | | W | | |
| Transmitter Pwr (dBW) | 23.0 | | dBW | | 14.0 | | dBW | | |
| Uplink Power Back-off | 1 | | dB | | 0 | | dB | | |
| # of Amplified Carriers | 1 | | | | 1 | | | | |
| Station Transmitter Losses | 0.3 | | dB | | Transmitter Total losses | 0.5 | dB | | |
| Station Antenna Diameter | 2.50 | | m | | Sat. Min. Ant. Gain | 33.5 | dBi | | |
| Station Peak Antenna Gain | 48.8 | | dBi | | Total EIRP of D/L | 47.0 | dBW | | |
| Operating EIRP per carrier | | | dBW | | Operating EIRP/carrier | 47.0 | dBW | | |
| Space Loss | 206.0 | 206.0 | dB | | Space Loss | 204.7 | dB | | |
| Atm. (Gas + Cloud) Att. | 0.3 | 0.3 | dB | | Atm. (Gas + Cloud) Attenuation | 0.2 | dB | | |
| Rain Attenuation | | 0.4 | dB | | Rain Attenuation | | dB | | |
| Pointing and Pol. Loss | | 2.8 | dB | | User Ant. Pointing Losses | 1.4 | dB | | |
| Sat. Antenna Gain | 26.2 | 26.2 | 'K | | Recvr. Antenna Gain | 47.3 | dBi | | |
| System Noise Temp | 365.1 | 365.1 | dBK | | System Noise Temp | 89.1 | 'K | | |
| System Noise Temp | 25.6 | 25.6 | dB/K | | System Noise Temp | 19.5 | dBK | | |
| Satellite G/T | 0.1 | 0.1 | dBK | | Station G/T | 27.5 | dBK | | |
| Boltzmann's Constant | -228.6 | -228.6 | dBW/K-Hz | | Boltzmann's Constant | -228.6 | dBW/K-Hz | | |
| Noise BW | 81.1 | 81.1 | dBHz | | Noise BW | 81.1 | dBHz | | |
| C/N (Thermal) | 11.4 | 9.6 | dB | | C/N (Thermal) | 16.7 | dB | 12.9 | dB |
| Total U/L C/I | 14.1 | | dB | | Uplink Conditions | clear | rain | clear | |
| U/L C/(Io) | | 95.2 | dB/Hz | | Downlink Conditions | clear | rain | clear | |
| Thermal U/L C/(No) | | 92.5 | dB/Hz | | U/L C/(No) (dB/Hz) | 92.5 | dB/Hz | 92.5 | dB/Hz |
| Total D/L C/I | 10.7 | | dB | | U/L C/(Io) (dB/Hz) | 95.2 | dB/Hz | 95.2 | dB/Hz |
| D/L C/(Io) | | 91.8 | dB/Hz | | U/L C/(No+Io) (dB/Hz) | 90.6 | dB/Hz | 90.6 | dB/Hz |
| Thermal D/L C/(No) | | 97.8 | dB/Hz | | D/L C/(No) (dB/Hz) | 97.8 | dB/Hz | 94.0 | dB/Hz |
| Required Eb/No | 6.5 | | dB | | D/L C/(Io) (dB/Hz) | 91.8 | dB/Hz | 91.8 | dB/Hz |
| Effective Data Rate | 112 | | Mbps | | D/L C/(No+Io) (dB/Hz) | 90.8 | dB/Hz | 89.8 | dB/Hz |
| Data Rate (dB) | 80.5 | | dB (bps) | | Total C/(No+Io) (dB/Hz) | 87.7 | dB/Hz | 87.2 | dB/Hz |
| Required C/(No+Io) | | 87.0 | dB/Hz | | Required C/No (dB/Hz) | 87.0 | dB/Hz | 87.0 | dB/Hz |
| Total Margin (dB) | | | | | Margin (dB) | 0.7 | dB | 0.0 | dB |
| Margin (dB) | | | | | Margin (dB) | 0.2 | dB | 0.0 | dB |

Table A-4. Ku-Band Telemetry Link

| Parameter | Spot Antenna | Bicone Pipe | Comments |
|---|-----------------|----------------|---|
| Minimum EIRP, dBW | 8.0 | 0.0 | Estimate |
| Path loss, dB/m ² | -162.5 | -162.5 | 40° elevation |
| Atmospheric absorption, dB | -0.5 | -0.5 | Estimate; clear sky |
| Isotropic areas, dB-m ² | 42.6 | 42.6 | @11450 MHz |
| Ground station G/T, dB/K | 34.9 | 34.9 | 7m antenna |
| Polarization mismatch, dB | 0.0 | 0.0 | |
| Boltzmann's constant, dBW/K-Hz | -228.6 | -228.6 | |
| Downlink C/No @ TM receiver, dB-Hz | 65.9 | 57.9 | |
| Minimum C/No @ TM receiver, dB-Hz | 53 | 53 | For 4 Kb/s stream |
| Clear weather C/No margin, dB | 12.9 | 4.9 | 1.1 dB rain fade for 99.95% availability |
| S/No for ranging: Receiver baseband S/No, dB-Hz | 60.7 | 52.7 | |
| Carrier recovery: TM receiver loop bandwidth, dB-Hz | 40.0 | 40.0 | 10 kHz PM demod PLL BW |
| Margin, dB | 16.7 | 8.7 | |
| Subcarrier recovery: TM receiver IF bandwidth, dB-Hz | 57.0 | 57.0 | 500 kHz BW |
| Margin, dB | 18.7 | 10.7 | |
| BER | | | |
| Minimum Eb/No for 10e ⁻⁶ BER dB | 10.5 | 10.5 | P.E. for coherent PSK = |
| Margin, dB | 11.6 | 3.6 | 0.5 * erfc(sqrt(Eb/No)) |

Table A-5. Ku-Band Command Links

On-Station Planar Array

| Contribution | Value | Comment |
|-----------------------------------|--------|------------------------------|
| Max Ground station EIRP, dBW | 83.9 | |
| Path loss, dB-m ² | -162.5 | 7 m antenna 40° elevation |
| Clear sky loss, dB | -0.5 | |
| Isotropic area, dB-m ² | 43.6 | 12750 MHz |
| Pointing error, dB | -0.1 | |
| BTA gain (sum path), dB | 35.0 | USDBS |
| Polarization loss, dB | -0.1 | |
| Path Loss to CR, dB | -16.3 | Ku band; includes SSMA |
| Power at TCR input, dBW | -104.2 | |
| CR command threshold, dBW | -135.0 | unit spec |
| Command margin, dB | 30.8 | |
| Command margin with rain fade, dB | 28.5 | 99.95% availability |

On-Station Pipe Antenna

| Contribution | Value | Comment |
|-----------------------------------|--------|------------------------------|
| Max Ground station EIRP, dBW | 83.9 | |
| Path loss, dB-m ² | -162.5 | 7 m antenna 40° elevation |
| Clear sky loss, dB | -0.5 | |
| Isotropic area, dB-m ² | 43.9 | 13250 MHz |
| Pointing error, dB | -0.1 | |
| Pipe antenna gain (sum path), dB | 4.0 | on-axis (Ku band) |
| Polarization loss, dB | -0.1 | |
| Path Loss to CR, dB | -6.3 | |
| Power at TCR input, dBW | -125.5 | |
| CR command threshold, dBW | -135.0 | unit spec |
| Command margin, dB | 9.5 | |
| Command margin with rain fade, dB | 6.9 | 99.95% availability |

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Appendix B
Interference Analysis

APPENDIX B: INTERFERENCE ANALYSIS

This appendix presents interference parameters, analyses, and results for scenarios involving Expressway™ and hypothetical GSO FSS systems.

Table B-1. Parameter List for V-band Expressway™ Interference Analysis

| LINK PARAMETER | UP LINK | | DOWN LINK | | UNITS |
|---------------------------------|-----------|---------|-----------|---------|-------|
| | Other GSO | Own GSO | Other GSO | Own GSO | |
| Orbital Separation | 2 | | 2 | | deg. |
| Signal frequency | 48.7 | 48.7 | 41 | 41 | GHz |
| Tx Power (Earth/Satellite) | 30 | 30 | 100 | 100 | W |
| Amplifier Backoff | 3 | 3 | 2 | 2 | dB |
| Tx Losses | 1 | 1 | 1 | 1 | dB |
| Number of Carriers | 1 | 1 | 10 | 10 | |
| Slant Range | 36000 | 36000 | 36000 | 36000 | km |
| Earth-Station Tx Antenna Size | 2.5 | 2.5 | | | m |
| Earth-Station Rx Antenna Size | | | 2.5 | 2.5 | m |
| Earth-Station Tx Ant. Peak Gain | 59.5 | 59.5 | | | dBi |
| Earth-Station Rx Ant. Peak Gain | | | 58.0 | 58.0 | dBi |
| Satellite Tx Ant. Peak Gain | | | 52 | 52 | dBi |
| Satellite Rx Ant. Peak Gain | 52 | 52 | | | dBi |
| Signal Bandwidth | 285 | 285 | 285 | 285 | MHz |
| Rx Noise Temperature | 650 | 650 | 460 | 460 | °K |

Table B-2. Parameter List for Ku-band (1° X 3° Beam) Interference Analysis

| LINK PARAMETER | UP LINK | | DOWN LINK | | UNITS |
|---------------------------------|-----------|---------|-----------|---------|-------|
| | Other GSO | Own GSO | Other GSO | Own GSO | |
| Orbital Separation | 2 | | 2 | | deg. |
| Signal frequency | 13 | 13 | 11 | 11 | GHz |
| Tx Power (Earth/Satellite) | 50 | 100 | 35 | 25 | W |
| Amplifier Backoff | 0 | 0 | 0 | 0 | dB |
| Tx Losses | 0.3 | 0.3 | 0.5 | 0.5 | dB |
| Number of Carriers | 1 | 1 | 1 | 1 | |
| Slant Range | 36000 | 36000 | 36000 | 36000 | km |
| Earth-Station Tx Antenna Size | 5 | 2.5 | | | m |
| Earth-Station Rx Antenna Size | | | 3 | 2.5 | m |
| Earth-Station Tx Ant. Peak Gain | 54.8 | 48.8 | | | dBi |
| Earth-Station Rx Ant. Peak Gain | | | 49.2 | 47.5 | dBi |
| Satellite Tx Ant. Peak Gain | | | 37 | 37 | dBi |
| Satellite Rx Ant. Peak Gain | 37 | 37 | | | dBi |
| Signal Bandwidth | 30 | 240 | 30 | 240 | MHz |
| Rx Noise Temperature | 1500 | 365 | 200 | 73 | °K |