Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Application of	)	
THE DIRECTV GROUP, INC.	)	Call Sign: S2191
For Minor Modification of Authorization to Launch and Operate a Ka-Band GSO FSS Satellite System at 103° W.L.	)	File No. SAT-MOD-2004_________

APPLICATION FOR MINOR MODIFICATION

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APPLICATION FOR MINOR MODIFICATION

The DIRECTV Group, Inc. ("DIRECTV") hereby requests that the Commission modify its authorization for a geostationary Ka-band satellite system at the 103° W.L. orbital location to allow DIRECTV to implement the minor changes set forth herein.[1] DIRECTV and its subsidiaries have already invested more than $1.5 billion in development, construction, and implementation of a Ka-band satellite system capable of delivering cutting-edge services to customers throughout the United States, and has committed additional tens of millions of dollars to complete the program. These investments will come to fruition with the completion and launch of the world's first Ka-band-only commercial satellites, including one located at 103° W.L. to be called SPACEWAY-1, by next spring. This request, which does not seek authority to use any additional orbital locations or additional spectrum beyond that for which DIRECTV is already authorized, is a minor modification to DIRECTV's existing license.

[1] DIRECTV is simultaneously withdrawing a prior Application for Minor Modification of this authorization in favor of the instant application. *See* FCC File No. SAT-MOD-20030401-00060.

Among other things, the proposed modifications will (1) update the system's design to incorporate state-of-the-art technology, such as the use of phased array antennas, and (2) relinquish spectrum no longer needed for inter-satellite links. As modified, the satellite system will give DIRECTV the flexibility to respond to its customers' needs with a highly advanced and efficient design.

Consistent with Commission rules,[2] DIRECTV intends to implement these changes, at its own risk, pending Commission action on this request in order to complete construction and launch of its modified satellites within the next year. Given the short timeframe in which it must accomplish these objectives in order to meet its launch milestone, DIRECTV requests that the Commission grant this application as expeditiously as possible.

I. BACKGROUND

In May 1997, as part of the first Ka-band satellite processing round, the Commission authorized Hughes Communications Galaxy, Inc. ("Hughes") to launch and operate a GSO satellite system to provide Fixed-Satellite Service.[3] Hughes proposed to use its system "to offer services such as direct-to-home services and high speed personal computer access to the Internet and on-line services, telephony, narrow-band data, high-speed data, videoconferencing, [and] high capacity two-way communications."[4] Among other things, Hughes received authority to operate a single Ka-band spacecraft at 67° W.L. As the result of a subsequent merger between Hughes' corporate parent, Hughes Electronics Corporation,

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2 47 C.F.R. § 25.113 (f).

3 *See Hughes Communications Galaxy, Inc.*, 13 FCC Rcd. 1351 (Int'l Bur. 1997), *modified*, 16 FCC Rcd. 2470 (Int'l Bur. 2001), *further modified*, 16 FCC Rcd. 12627 (Int'l Bur. 2001). Hughes was initially authorized to operate in the 28.35-28.6/29.25-30.0 GHz bands for uplinks and in the 19.7-20.2 GHz band for downlinks.

4 *Id.* at 1352.

and PanAmSat Corporation ("PanAmSat"), Hughes assigned a portion of its Ka-band authorization (including the 67° W.L. slot) to PanAmSat.[5] In a December 1997 order, the Commission granted PanAmSat's request to reassign its satellite at 67° W.L. to 103° W.L.[6]

In January 2001, the Commission established milestone requirements for PanAmSat's Ka-band satellite authorizations. Specifically, it required PanAmSat to commence construction of its first satellite by January 2002 and, with respect to the 103° W.L. orbital location, to launch and operate a satellite by June 25, 2005.[7] In June 2002, the Commission found that PanAmSat had satisfied its first milestone.[8]

On March 18, 2003, the Commission granted its consent to the *pro forma* assignment of this license from PanAmSat to Hughes Network Systems, Inc. ("HNS").[9] Earlier this year, the Commission granted its consent to the *pro forma* assignment of this license from HNS to DIRECTV.[10]

DIRECTV has three SPACEWAY Ka-band spacecraft currently under construction by Boeing Satellite Systems ("Boeing"), one of which DIRECTV has named SPACEWAY-1 and designated for use at 103° W.L.[11] By this application, DIRECTV seeks to modify its Ka-

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5 *See Hughes Communications, Inc. and Affiliated Companies*, 12 FCC Rcd. 7534 (1997).

6 *See Assignment of Orbital Locations to Space Stations in the Ka-Band*, 12 FCC Rcd. 22004 (Int'l Bur. 1997), *further amplified*, DA 01-949 (Int'l Bur., rel. April 17, 2001). PanAmSat also received authority to operate downlinks in the 18.3-18.8 GHz band and inter-satellite links several bands. *See PanAmSat Corp.*, 16 FCC Rcd. 2490 (Int'l Bur. 2001).

7 *PanAmSat Corp.*, 16 FCC Rcd. at 2499-2500.

8 *See* Public Notice, 17 FCC Rcd. 11272 (Int'l Bur. 2002).

9 *See* FCC File No. SAT-ASG-20030310-00022.

10 *See* FCC File No. SAT-ASG-20040520-00101.

11 DIRECTV's subsidiary, DIRECTV Enterprises, LLC, also has a hybrid BSS/Ka-band satellite under construction by Space Systems/Loral, which has been designated for launch to the 101° W.L. orbital location, that is scheduled to be launched by June 2005. The Loral spacecraft and another Boeing

band authorization at 103° W.L. to conform it to the design and parameters of the SPACEWAY-1 spacecraft currently under construction at Boeing.

The proposed modifications are designed to optimize the satellite's capabilities in light of advances in technology and recent changes in the marketplace for broadband and other satellite services. They incorporate state-of-the-art engineering to achieve enhanced flexibility of service offerings. Among the changes involved in this modification are: (1) the use of phased-array antennas for downlink transmissions through small, hopping spot beams with higher EIRP, and greater antenna pointing accuracy and control; (2) the addition of a downlink broadcasting capability through a single or multiple wide-area beams on each polarization to cover wide geographic areas; (3) new bandwidth partitioning and frequency re-use schemes for uplink and downlink signals; (4) the ability to operate either with or without on-board processing; and (5) an improved telemetry, tracking and command system.

In addition to the changes detailed in this application, a number of system elements have been incorporated into the spacecraft design to improve the service function and extend the design life of the spacecraft. Among these added features are the use of the Boeing 702 model spacecraft (rather than a 601 model as originally contemplated), improved bus payload support, higher weight and power capability, state-of-the-art thermal management and load dissipation, and improved management of ephemeris and attitude determination.

The modifications proposed in this application will allow DIRECTV to best meet the needs of satellite users. The system, with proposed modifications, is fully compliant with Commission rules relating to Ka-band blanket earth station licensing.

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spacecraft to be launched to 99° W.L. are the subjects of separate modification applications. The third Boeing spacecraft is a ground spare.

II. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

DIRECTV and its affiliates have invested years of effort and over $1.5 billion in developing and implementing a Ka-band satellite system.[12] Most recently, following News Corporation's investment in DIRECTV, Boeing has been instructed to incorporate final design changes that will expand the satellite's capabilities while still achieving delivery of the SPACEWAY-1 satellite in time for launch in the first quarter of 2005. DIRECTV has also made arrangements for a launch with the Sea Launch Company in that timeframe. Thus, DIRECTV has put into place all of the financial, contractual, and organizational resources necessary to achieve the launch and operation of the SPACEWAY-1 satellite prior to the expiration of its June 25, 2005 operational milestone. Combined with the launch of DIRECTV's other Ka-band satellites, this will mark the true inauguration of the band for commercial services.

The modifications proposed in this application will help to ensure that SPACEWAY-1 will operate efficiently and effectively and will be able to provide a wide variety of services. For example, its innovative use of phased-array antennas will allow DIRECTV to choose the size of its downlink service areas, from as small as 0.5° spots to as large as CONUS. The design has also been modified to allow DIRECTV to operate either with or without the use of on-board processing, affording still more options for consumer services in addition to backhaul and other capabilities that will enhance DIRECTV's operations. With the advanced and flexible design of this satellite, DIRECTV will be better able to respond to the rapidly changing needs of its customers in the satellite services markets.

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[12] *See* Letter from Michael L. Cook to Thomas S. Tycz, FCC File No. SAT-LOA-19931203-00040 (dated Feb. 20, 2004).

While this minor modification will provide valuable benefits, it will create no offsetting public interest concerns. It will not increase harmful interference into adjacent satellite systems. It does not seek authority to use any additional orbital locations or additional spectrum beyond that for which DIRECTV is already authorized. Indeed, as part of the proposed modification, DIRECTV will relinquish spectrum that it is currently authorized to use for inter-satellite links. Accordingly, this proposal is fully consistent with long-established Commission precedent that allows licensees to modify the design of their licensed systems during the construction phase to take into account state-of-the-art technology and to otherwise optimize their systems.[13] Consistent with Commission rules[14] and in order to meet its launch milestone, DIRECTV intends to implement these changes, at its own risk, pending Commission action on this request.

For the foregoing reasons, DIRECTV requests that the Commission grant this application as expeditiously as possible.

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13 *See, e.g., EchoStar Satellite Corp.*, 18 FCC Rcd. 15862 (Int'l Bur. 2003) (minor modification of Ka-band satellite license to conform to actual construction); *R/L DBS Company, LLC*, 18 FCC Rcd. 7694 (Int'l Bur. 2003) (minor modification allowed to incorporate latest technology so long as no significant increase in interference); *Teledesic LLC*, 14 FCC Rcd. 2261, 2263-64 (Int'l Bur. 1999)(finding a minor modification where changes will not significantly increase interference to other systems); *Hughes Communications Galaxy, Inc.*, 5 FCC Rcd. 1653 (1990)(permitting increase in transponder power from 10 watts to 16 watts).

14 47 C.F.R. § 25.113 (f).

III. INFORMATION REQUIRED BY SECTION 25.114(C) OF THE COMMISSION'S RULES

1. Name, Address and Telephone Number of Applicant

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3. Type of Authorization Requested

DIRECTV seeks to modify its existing license to launch and operate a non-common carrier Ka-band satellite system at the 103° W.L. orbital location, using the 18.3-18.8 GHz and 19.7-20.2 GHz downlink bands and the 28.35-28.6 GHz and 29.25-30.0 GHz uplink bands. DIRECTV also hereby relinquishes that portion of its Ka-band license authorizing the use of spectrum for inter-satellite links at this orbital location.

4. General Description of Overall System and Facilities, Operations and Services

The SPACEWAY satellite system will consist of two in-orbit satellites (and one ground spare), located at 99° W.L. and 103° W.L., capable of providing international and domestic Fixed-Satellite Services to North America, including Alaska, Hawaii, and Puerto Rico. This minor modification addresses only the SPACEWAY-1 satellite to be positioned at 103° W.L.

The satellite will operate in the 18.3-18.8 GHz and 19.7-20.2 GHz bands (space-to-Earth), and 28.35-28.6 GHz and 29.25-30.0 GHz bands (Earth-to-space). The system uses both LHCP and RHCP polarization together with beam separation to achieve frequency re-use at acceptable levels of co- and cross-polarized intra-system interference isolation. The satellite will support a full on-board processor mode, whereby half of the uplink spectrum will be received by the satellite, fully demodulated, and "re-packaged" for re-transmission back to Earth. In this mode of operation there are no "transponders," in the classical sense of the word, on the satellite. The satellite can also be operated in a non-processor mode whereby this same spectrum can be viewed as being composed of eight 62.5 MHz channels that are re-used multiple times on the uplink and downlink. The precise amount of frequency re-use in this mode is dependent upon the overall geographical distribution of uplink and downlink traffic. The satellite also includes wideband (*i.e.*, 165 MHz) uplink and downlink channels, which can support virtually any mix of carriers that will fit within the channel bandwidth.

As with the original SPACEWAY satellite system, DIRECTV proposes to use the modified SPACEWAY-1 satellite "to offer services such as direct-to-home services and high speed personal computer access to the Internet and on-line services, telephony, narrow-band data, high-speed data, videoconferencing, [and] high capacity two-way communications."[15]

A variety of user terminal antenna sizes between 0.74 to 3.5 meters have already been licensed for use with the SPACEWAY satellite system (see also Section 7.3), and DIRECTV may apply for further authorizations with different antennas in the future. The appropriate size can be chosen to ensure the desired availability as well as achieve the desired performance at the preferred data rate. Any additional antennas for which authorization may

15 *See Hughes Communications Galaxy, Inc.*, 13 FCC Rcd. 1351, 1352 (Int'l Bur. 1997).

be sought in the future are expected to be fully compliant with the off-axis EIRP coordination thresholds in the FCC's rules relating to Ka-band blanket licensing.

The overall capacity of the system is dependent upon a number of factors. For example, the downlink power flux density ("PFD") on the surface of the Earth is higher when the downlink phased array is operated in spot beam mode, as compared to wide area beam mode. This higher downlink PFD can support higher data rates, and consequently higher capacity. However, depending upon the mix of traffic that is being transmitted, the phased array can spend varying amounts of time in spot beam vs. wide area beam coverage, and hence the system can have varying overall capacity. In addition to this, when operated in the non-processor mode, the overall capacity of the system will again be dictated by the mix of traffic that is being supported at any given time. In general terms, the maximum overall capacity that can be achieved with the satellite is greater than 10 Gbps.

5. Operational Characteristics

5.1 Frequency and Polarization Plan

The overall frequency and polarization plan for the satellite is shown in Table 5.1-1, indicating channel center, upper, and lower frequencies, as well as channel polarizations. Note that Bands B1 and B2 are wideband channels that can support virtually any mix of carrier types within the passband of the overall channel. Also note that on the uplink, both of these bands employ a 10 MHz guard band at the lower edge of the band, and a 75 MHz guard band at the upper edge of the band. As can be seen from the Table, after frequency translation to the downlink frequency band, this guard band spectrum is essentially equally distributed between the upper and lower edges of bands B1 and B2. This design results in an overall bandwidth on the order of 165 MHz for each of bands B1 and B2. While this bandwidth does not occupy the entire range of frequencies assigned to DIRECTV in this portion of the band, certain design trade-offs were necessary due to limitations of space and power available on the satellite as well as practical limitations on the availability of long-lead items in light of the impending launch milestone. DIRECTV intends to launch follow-on spacecraft that will operate over the entire assigned bandwidth in the B1 and B2 bands.

Band Designator	**B1**	**B2**	**B3**	**B4**
Uplink Frequency Range (GHz)	28.36-28.525	29.26-29.425	29.5-29.75	29.75-30.0
Uplink Polarization	LHCP	LHCP/RHCP	LHCP/RHCP	LHCP/RHCP
Transponder Bandwidth	165 MHz	165 MHz	N/A for processor operation. 62.5 MHz for non-processor operation.	N/A for processor operation. 62.5 MHz for non-processor operation.
Transponder Center Frequency	28.4425 GHz	29.5075 GHz	N/A for processor operation. Channels centered every 62.5 MHz for non-processor operations.	N/A for processor operation. Channels centered every 62.5 MHz for non-processor operations.
Downlink Frequency Range (GHz)	18.365-18.53	18.57-18.735	19.7-19.95	19.95-20.2
Downlink Polarization	RHCP/LHCP	RHCP/LHCP	RHCP/LHCP	RHCP/LHCP
Transponder Bandwidth	165 MHz	165 MHz	N/A for processor operation. 62.5 MHz for non-processor operation.	N/A for processor operation. 62.5 MHz for non-processor operation.
Transponder Center Frequency	18.4475 GHz	18.6525 GHz	N/A for processor operation. Channels centered every 62.5 MHz for non-processor operations.	N/A for processor operation. Channels centered every 62.5 MHz for non-processor operations.

Table 5.1-1 Ka-Band Frequency and Polarization Plan

Band B1 is received on LHCP and, depending upon the location of the uplink, Band B2 can be received on either LHCP or RHCP. These uplink frequency bands are translated down to the upper and lower halves of the 18.3-18.8 GHz band, respectively, for transmission back to Earth. These frequency bands are transmitted via a wide area beam (see also Section 7.2). The downlink polarization for these bands is either LHCP or RHCP.

Bands B3 and B4 are contiguous on both the uplink and the downlink. These bands are received by the satellite in the 29.5-30.0 GHz range and are translated down to the 19.7-20.2 GHz range for re-transmission to Earth. When the satellite is operated in full processor mode, the uplink and downlink transmissions are essentially separated by the on-board processor. In this mode, the uplink in each beam is FDMA/TDMA (see also Section 5.2.1 for frequency plan) and the downlink is either a hopping or broadcast TDM carrier (see also Section 5.2.2 for discussion). As such, when operated in this mode there are no "transponders," in the conventional sense of the word, on the satellite. When the satellite is operated in non-processor mode it can be viewed as supporting eight contiguous 62.5 MHz channels. These channels can support virtually any mix of carrier types within the passband of a given 62.5 MHz channel. In this mode, single or multiple channels can be received by the satellite in a given uplink beam, channels can be re-used among uplink beams, and these uplink channels can be connected to any downlink channel and routed to virtually any downlink beam.

Given that the downlink antenna used for the 19.7-20.2 GHz band is a phased array, it can produce an almost infinite number of possible beam configurations (see also Section 7 for representative antenna patterns). This phased array antenna can produce both RHCP and LHCP transmissions and can be configured to create up to twenty-four 0.5^{o} spot beams, or multiple regional or wide area beams, virtually anywhere within the coverage area of the satellite. The beam polarization and placement, and the actual input channels routed to any given downlink channel or beam, can be controlled from the ground but is dictated by limitations on intra-system interference.

5.2 Communications Payload

5.2.1 Uplink Transmissions

In the processor mode in the 29.5-30.0 GHz frequency band, the satellite supports three uplink signal data rates of 520.83 kbps, 2.083 Mbps and 16.666 Mbps using an FDMA-TDMA format. In this mode, each uplink beam will use one to six 62.5 MHz sub-bands, depending on the user demand within that beam (see Figure 5.2-1). Adjacent beams with the same polarization in the uplink beam grid will carry signals using separate sub-bands (see also Figure 7.1-1 in Section 7).

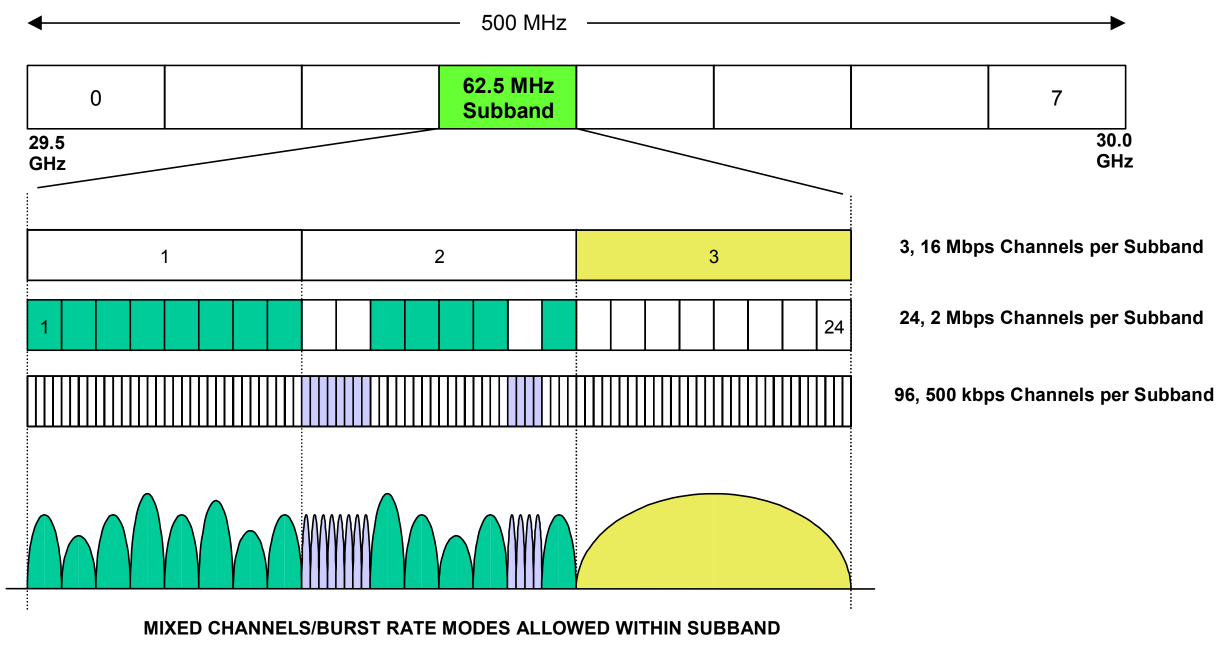

Figure 5.2-1 Representative Frequency Plan for Processor Mode Operations

Derivatives of QPSK modulation with forward error correction coding will be used for uplink signaling in this mode. For uplink spot beam antenna directivity contours, see Section 7. The three emission designators associated with these processing mode communications uplinks are: 651KG7W, 2M60G7W, and 20M8G7W, with associated allocated bandwidths of 651 kHz, 2.6 MHz and 20.8 MHz, respectively.

In the non-processor mode of operation, the satellite can be considered as a more conventional "bent-pipe" type of satellite with full interconnection capability between receive and transmit channels. In this mode, the 29.5-30.0 GHz band can be viewed as consisting of eight adjacent 62.5 MHz channels. Virtually any mix of carrier types can be supported within the passband of a given channel. In this mode, the major limitation to re-use of the uplink spectrum is the requirement to have a minimum "re-use distance" between uplink beams containing the same frequency and polarization. The emission designator associated with this type of operation is 24M0G7W with an associated allocated bandwidth of 24 MHz.

In either processor or non-processor mode of operation, the received uplink signals are filtered by bandpass filters centered on each of the 62.5 MHz sub-bands (or channels). This filtering is done at an intermediate frequency and a representative filter characteristic is shown in Appendix D as Figure D-1.

The 28.35-28.6 GHz and 29.25-29.5 GHz bands each support a single 165 MHz wideband channel. Virtually any mix of carrier types can be supported within the passband of these channels and these channels will be used to support backhaul operations for transporting remotely collected signals back to DIRECTV's broadcast centers. The 28.35-28.6 GHz band will be received by a fixed pointed antenna (see Section 7.1), and the 29.25-

29.5 GHz band can be received by any of the 112 uplink spot beams. The emission designators of the signals to be transmitted through these channels are: 24M0G7W, 36M0G7W and 54M0G7W with associated allocated bandwidths of 24 MHz, 36 MHz and 54 MHz, respectively. The receive filter characteristics for the 28.35-28.6 GHz band are shown in Appendix D as Figure D-2, and those for the 29.25-30.0 GHz band are shown in Appendix D, Figure D-3. Both of these filters were the best achievable under the schedule constraints of the satellite development program.

5.2.2 Downlink Transmissions

For downlink transmissions in the 19.7-20.2 GHz band in processor mode, each of the 24 hopping 0.5-degree spot beams will always be operated, through an adaptive power-control mechanism, at the minimum required EIRP and at beam peak, to close the link at the desired performance threshold under clear and rainy weather conditions in different parts of the coverage area. For representative downlink spot beam antenna directivity, see Section 7. In this mode, a single wideband 400 Mbps carrier is transmitted in each beam. The beam dwells at each location long enough to service the terminals at that location.

As discussed in Section 7, the downlink phased array antenna can also be configured to produce a wide area beam, which can be operated in two different transmission rates of 133.333 or 100 Mbps. These modes have identical service areas and will be configured to cover the area of greatest concentration in required service. For an example of a wide-area CONUS beam service area, see Section 7.

Forward error correction coding will be used for all downlink communication links. In processor mode, the downlink emission designators for communications links in the 19.7-20.2 GHz band will be 167MG7W and 125MG7W for the wide-area coverage beams and

500MG7W for spot beams with associated allocated bandwidths of 167 MHz, 125 MHz and 500 MHz, respectively. For a representative collection of spot beams used for coverage from the 103° W.L. orbital location, see Section 7. All uplink beams can be simultaneously activated at all times. In processor mode, the satellite performs no transmit filtering, *per se*. All spectral shaping for the processor mode is achieved via digital signal processing within the on-board modulator.

For non-processor operations, the 19.7-20.2 GHz band can be viewed as supporting eight contiguous 62.5 MHz channels. Multiple channels can be received in a given uplink beam, and these channels can be re-used among uplink beams, subject to the requirement that a minimum re-use distance be maintained between co-frequency/co-polarized beams. Once received, these 62.5 MHz channels can be individually frequency translated to any one of eight contiguous 62.5 MHz downlink channels and routed to specific downlink beams. In the downlink direction, the phased array antenna is capable of producing multiple downlink beams (up to 24 of them) of virtually any shape. The satellite will therefore be operated so as to optimize the downlink coverage in support of the overall traffic being carried. In this mode, the downlink emission designator for the band 19.7-20.2 GHz will be 24M0G7W with an associated allocated bandwidth of 24 MHz. The satellite output filtering for the 19.7-20.2 GHz band for non-processor operations is shown in Appendix D, Figure D-4. Note that in this case, the satellite output filtering is actually performed at baseband, as all received channels are converted to baseband before being upconverted to their final output frequency.

The 18.3-18.8 GHz downlink band will be connected to the 28.35-28.6 GHz and 29.25-29.5 GHz uplink bands, with the lower 250 MHz segment of the uplink band being connected to the lower 250 portion of the downlink band and likewise for the upper 250 MHz band segments. This segment of spectrum will support DIRECTV backhaul operations for routing remotely collected signals to DIRECTV's broadcast centers. The coverage pattern for the downlink antenna to be used for these backhaul operations is shown in Section 7. The emission designators for this downlink band will be 24M0G7W, 36M0G7W and 54M0G7W with associated allocated bandwidths of 24 MHz, 36 MHz and 54 MHz, respectively. The satellite output filter characteristics for this transmit band are shown in Appendix D, Figure D-4. Note that in this case, the satellite output filtering is actually performed at baseband, as all received channels are converted to baseband before being upconverted to their final output frequency.

5.3 Telemetry, Tracking, and Control Payload

The telemetry, tracking and control subsystem has been refined as described below. The sub-system now provides for both transfer orbit and on-station operation at Ka-band.[16] The details for the radio frequency subsystem integration are shown in Figure 5.3-1. The proposed portion of the communication system frequency plan that is shared with the communication primary payload is defined in Appendix C. The subsystem utilizes both circular and linear (horizontal) polarization and provides beacon tracking for assisting in antenna pointing and spacecraft attitude determination. The three emission designators associated with the TT&C system are: 1M30F9D for command, 106KG9D for telemetry, and 000N0N for the uplink unmodulated beacon.

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[16] *See Hughes Communications Galaxy, Inc.*, 13 FCC Rcd. 1351, 1359-1360 (1997) (denying without prejudice request for Ku-band TT&C).

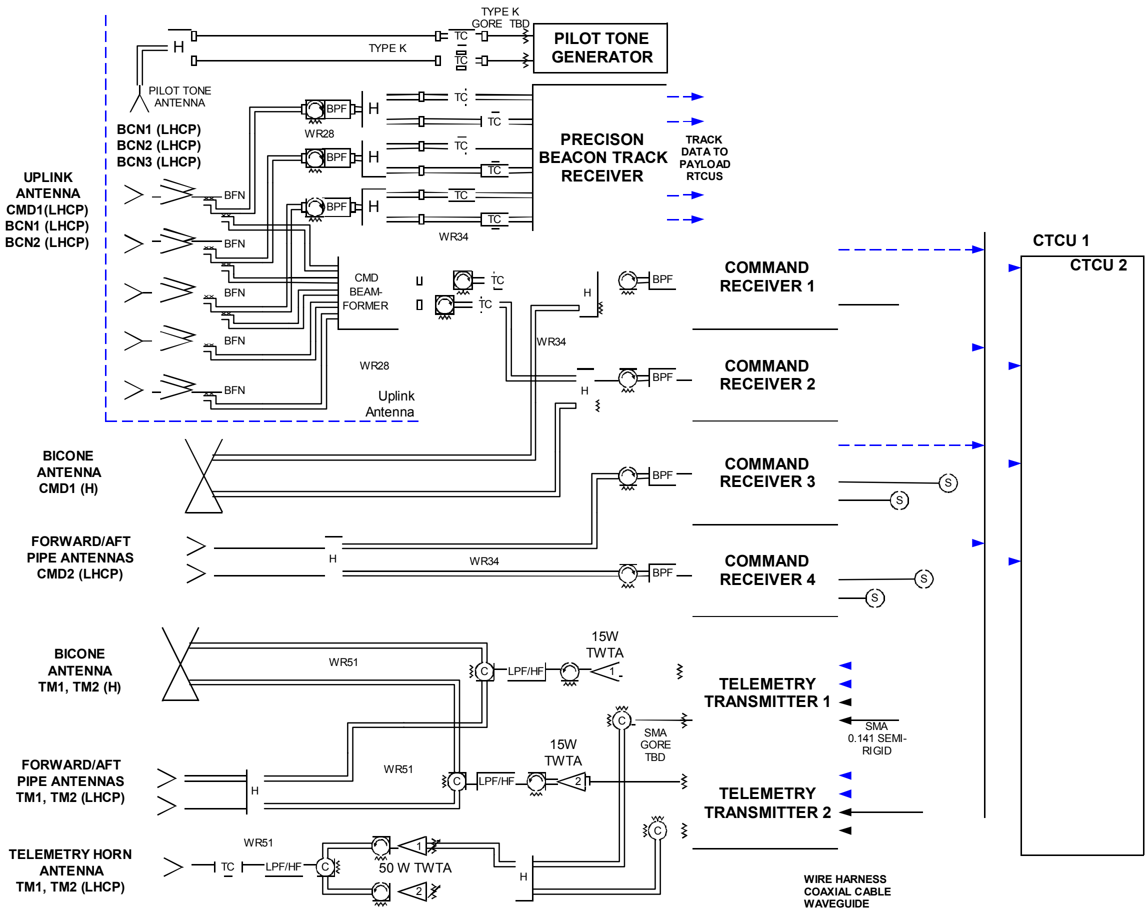

Figure 5.3-1 TT&C R.F. Sub-system

6. Orbital Locations

The SPACEWAY-1 satellite has been designed to operate at the nominal 103° W.L. orbital location, which has been previously assigned to DIRECTV for Ka-band satellite operations.

7. Predicted Spacecraft Antenna Gain Contours

7.1 Uplink Traffic Beams

In the uplink direction for the 29.25-30.0 GHz frequency range, the 112 cells that are created by the satellite on the surface of the Earth are grouped in LHCP and RHCP polarized stripes as shown in Fig. 7.1-1.

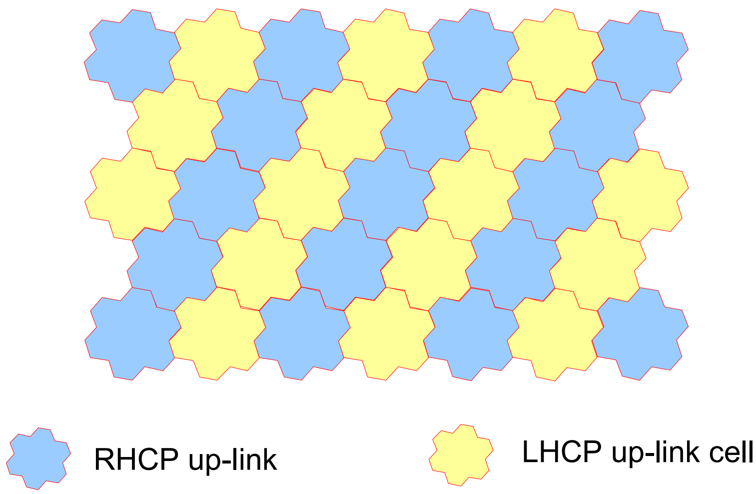

Figure 7.1-1 Hexagonal Array of Spacecraft Receive Beam Service Cells

Details of the uplink spot beam antenna directivity contours for the beams that support this frequency band are given in Figure B-2.1 of Appendix B. A representative collection of spot beams used for coverage from the 103° W.L. orbital location is shown in Figure B-3.1 of Appendix B. All uplink beams can be simultaneously activated at all times.

The uplink antenna coverage contour for the receive antenna that supports the 28.35-28.6 GHz band is provided in Appendix B, Section 5, Figure B-5.1. As can be seen in that Figure, this receive antenna produces two main receive peaks. This is done by using a careful combination of multiple receive feeds and results in relatively high gain for each of the beam peaks.

7.2 Downlink Traffic Beams

The downlink antenna for the 19.7-20.2 GHz band is a 1500 element active phased array. This array is extremely flexible and can be configured from the ground to create up to twenty-four 0.5^{o} spot beams, a single wide area CONUS beam, or virtually any beam combination in between these two extremes. The details of the downlink spot beam antenna directivity contours for the beams that support the 19.7-20.2 GHz band are given in Figure B-2.2 of Appendix B. In this configuration, the coverage area over all downlink cells is overlapping and aligned with the coverage area of all uplink cells (see also Figure B-3.1). Figure B-4.1 of Appendix B gives an example of a wide-area CONUS beam for the frequency band 19.7-20.2 GHz.

The downlink antenna coverage contour for the transmit antenna that supports the 18.3-18.8 GHz band is provided in Appendix B, Section 6, Figure B-6.1. As can be seen, this is a wide area beam that essentially includes all of CONUS within its -2 dB footprint.

7.3 TT&C Beams

The antenna pattern characteristics for the on-station mode of operation of the TT&C subsystem are provided in Figure B-5.1 and B-6.1 of Appendix B. In addition to the on-station antenna beams, the TT&C subsystem also employs a dual omni antenna configuration consisting of a standard bicone antenna and forward and aft pipe antennas with nearly 4π steradian coverage. The bicone antenna is linearly polarized and the forward and aft pipes are LHCP. The gain of these antennas is relatively low (on the order of 5 dB for the pipes and 0 to -1 dB for the bicone) and the coverage patterns are shown in Figure B.7-1.

8. Service Description, Link Description and Performance Analysis, Earth Station Parameters

8.1 Service Description

As with its original Ka-band satellite system, DIRECTV proposes to use its modified system "to offer services such as direct-to-home services and high speed personal computer access to the Internet and on-line services, telephony, narrow-band data, high-speed data, videoconferencing, [and] high capacity two-way communications."[17] The modified Ka-band satellite described herein will provide DIRECTV the flexibility to operate in a variety of modes, matching the optimal characteristics to the service to be delivered to the consumer.

8.2 Link Performance

Tables A-1 to A-9 in Appendix A illustrate representative link budgets for a variety of services and carrier types and demonstrate compliance with, and anticipated margin relative to, the required downlink PFD coordination threshold contained in Section 25.138 of the FCC's rules. Appendix A demonstrates that using the requested system modifications, DIRECTV will remain in compliance with the relevant FCC technical rules applicable to satellites operating with blanket licensed earth stations.

The modified SPACEWAY-1 satellite will support a variety of uplink data rates ranging from 520.8 kbps to 90 Mbps. The supportable uplink data rate is dependent on the size of the transmitting antenna and its associated transmitter, the rain zone, the link elevation angle, and the location of the transmit antenna relative to the gain contour of the satellite's receive beam. Tables A-1 through A-9 in Appendix A provide representative link budgets

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[17] *See Hughes Communications Galaxy, Inc.*, 13 FCC Rcd. 1351, 1352 (Int'l Bur. 1997).

for different uplink data rates and antenna sizes. The assumptions used for each link budget are indicated on the link budget worksheet.

Tables A-1 through A-5 illustrate typical link budgets for the satellite operated in processor mode and supporting a variety of earth station sizes and uplink data rates. Tables A-1 through A-3 show uplink budgets for the three different terminal sizes supporting three different uplink data rates. Compliance with the off-axis EIRP coordination threshold values of Section 25.138 is also shown in these Tables. Tables A-4 and A-5 show the downlink case with the spacecraft supporting point-to-point links and a broadcast CONUS operation. Note that the assumed link availability is at least 99.5%. Compliance with the downlink PFD coordination threshold value of Section 25.138 is shown in these tables (*see also* Section 10).

Table A-6 shows the case of the satellite operated in the DTH non-processor mode. In this case the uplink signal originates from a broadcast center using a fairly large transmit antenna and the downlink is received by a relatively small subscriber unit. Note that the assumed link availability in this case is 99.9%. Compliance with the coordination threshold values contained in Section 25.138 is also shown in this Table (*see also* Section 10).

Tables A-7 through A-9 show the link analysis results for the backhaul case supporting three different transmission rates. In this case both the transmit and receive sides of the link employ sizable antennas. Note that the link availability for all three of these cases is assumed to be 99.8%. Compliance with the coordination threshold values contained in Section 25.138 is also shown in these Tables (*see also* Section 10).

8.3 Earth Station Parameters

A variety of user terminal antenna sizes between 0.74 to 3.5 meters have already been licensed for use with the SPACEWAY system.[18] The appropriate size can be chosen to ensure the desired availability as well as to achieve the desired performance at the preferred data rate. Authority to communicate with additional terminals with different characteristics may also be sought in the future. Any additional antennas for which authorization may be sought in the future are expected to be fully compliant with the off-axis EIRP coordination thresholds in the FCC's rules relating to Ka-band blanket licensing.

In addition, there will be a small number of medium and large gateway or backhaul earth stations that will be used for transporting remotely collected signals back to the system broadcast center. These earth stations will use approximately nine meter antennas to provide the desired overall link performance, depending on system requirements.

9. Satellite Orbit Characteristics

As required by Section 25.210(j) of the FCC's rules, the satellite will be maintained in synchronous orbit at its nominal orbital location within a longitudinal drift tolerance of $\pm$ 0.05^{o} and at zero orbital inclination, within a tolerance of $\pm$ 0.05^{o}. The antenna axis attitude will be maintained within ± 0.03° of nominal during normal mode and within ± 0.03° of nominal during orbit maneuvers (*i.e.,* stationkeeping).

10. Power Flux Density Compliance

The downlink beams operating in the 19.7-20.2 GHz band are generated by a phased array antenna comprising 1500 active elements. Each element is driven by a solid state

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18 *See* Public Notice, Rep. No. SES00490 (April 16, 2003)(call sign E030007); Public Notice, Rep. No. SES-00520 (July 30, 2003)(call sign E030008).

power amplifier module, and the modules are grouped into three maximum output power levels. This grouping was done to maximize the antenna sidelobe performance. The maximum output power for the modules at each of these three levels is 1.06, 0.45 and 0.11 watts.

When used in processor mode, this active antenna will be operated so as to generate a maximum EIRP in any downlink 0.5^o spot of 70.2 dBW, and to thereby comply with the Ka-Band blanket licensing coordination threshold of –118 dBW/m^2/MHz, as demonstrated in Table A-4 of Appendix A. The nominal EIRP for the wide-area CONUS beams is 63.3 dBW. Operation with this EIRP complies with the FCC requirements as demonstrated in the link summary and compliance budget in Table A-5 of Appendix A. In all cases the upper bound on system and individual link availability is determined by –118 dBW/m^2/MHz, *i.e.* the downlink PFD coordination threshold established in Section 25.138 of the FCC's rules.

When the phased array antenna is supporting non-processor mode transmissions, it will be operated so as to limit the satellite transmit power in any 24 MHz carrier to approximately 58.4 dBW (depending upon geographic location). As is shown in Table A-6 of Appendix A, this imposed limitation will ensure compliance with the FCC downlink PFD coordination threshold of -118 dBW/m^2/MHz at all times.

The downlink operating in the 18.3-18.8 GHz band will also comply with the downlink PFD limits established in Section 25.208 of the FCC's rules, which are as follows:

- -115 dB (W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (d-5) dB (W/m^2) in any 1 MHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB (W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

In this frequency band, the satellite uses a 15 Watt traveling wave tube amplifier. After including the losses between the amplifier output and the transmit antenna input (approximately 1.7 dB), and the transmit antenna gain (see Section 7.2), the maximum satellite EIRP in any direction in this band is approximately 27 dBW.[19] The analyses included in Tables A-7 to A-9 clearly illustrate that this operation will result in a PFD on the surface of the Earth that is well within the FCC requirements stated above.[20]

11. Arrangement for Telemetry, Tracking and Control

The TT&C payload characteristics are described in Section 5.3 above. DIRECTV has entered into a contract with The Boeing Company to provide the equipment, facilities, long term operations and maintenance services for the SPACEWAY satellites. The operations and maintenance services will be provided by a Boeing division called Boeing Space and Communications Services (BS&CS) located at the Johnson Space Center in Houston, Texas. All facilities necessary for the TT&C operation of the SPACEWAY satellites have been completed by Boeing and are ready for operation. The Operations Control Center, located in a Boeing-owned facility at the Johnson Space Center is the primary point of control. The primary TT&C earth station is located in Littleton, CO at site under lease to Boeing. The backup TT&C site is located in Canoga Park, CA at a Boeing-owned site and the alternate recovery facility is also co-located at this site. In addition, Boeing has designed a

19 Follow-on spacecraft will operate at higher PFD levels, but will be fully compliant with the Commission's rules and coordination thresholds.

20 It should be noted that the maximum PFD value is also below the value given in § 25.138(a)(6) for blanket licensing of small user terminals.

transportable earth station that can be deployed to either TT&C site in the event of a major failure.

12. Physical Characteristics of the Space Station

DIRECTV has revised the spacecraft bus characteristics to support the growing capacity and evolving complexity of the communication systems. Table 12-1 summarizes the key spacecraft characteristics.

Table 12-1. Summary of SPACEWAY-1 Characteristics

SPACEWAY-1	
Spacecraft:	Boeing 702 model
Launch:	
Vehicle	Sea Launch
Site	Pacific Ocean
Orbital slot:	103 degrees West longitude
Contract life:	12.6 years

PAYLOAD	
Ka-band	18.3-18.8 GHz and 19.7-20.2 GHz (space-to-Earth), 28.35-28.6 GHz, 29.25-30.0 GHz (Earth-to-space)

POWER	
Solar Array: **Array Power Available** **Payload Load** **Bus Load** **Total Load (Watts)** **Array Power Available (Watts)**	2 wings each w/5 panels of triple-junction gallium arsenide solar cells 11 kW 8.6 Kw (worst case EOL @ equinox) 4.2 kW (worst case EOL @ equinox) 12.8 kW (worst case EOL @ equinox) 14.4 kW (worst case EOL @ equinox)
Batteries: **Depth of Discharge (%)**	45 cell NiH2 73

DIMENSIONS	
In-orbit	L, solar arrays: 135 ft (41 m) W, antennas/radiators: 26 ft (8 m) H, antenna 23 ft (7 m)
Stowed	H: 17 ft (5.1 m) W: 9 ft (2.7m)
Mass **At Launch**	6060 kg
In-orbit (beginning of life)	3895 kg
End of life	3635 kg

ANTENNAS
Receive – Multi-beam side fed offset Cassegrain antenna **Transmit** – 19.7-20.2 GHz Phased array, two meter diameter, forms multiple hopping spot or shaped beams. 18.3-18.8 GHz wide beam potter horn.

13. Spacecraft Bus Subsystem

The SPACEWAY payload is supported by the Boeing 702 bus. A triple junction Gallium Arsenide (GaAs) solar array provides the required electrical power to the satellite. A nickel-hydrogen battery in the packs provides eclipse power. On-station downlink beam pointing is sensed by a Star Tracker and controlled by a Spacecraft Control Processor (SCP) and Payload Control Computer (PCC). On-station uplink beam pointing and satellite attitude is sensed by a Precision Beacon Tracker and Star Tracker (yaw sensing) and controlled by the SCP and a set of reaction wheels to steer the spacecraft body. Four Xenon Ion Propulsion Subsystem (XIPS) thrusters provide momentum dumping and stationkeeping. The Liquid Propulsion Subsystem (LPS) is nominally used only during transfer orbit and emergency station changes. Centrally controlled heaters, fixed and deployable radiators, heatpipes, and thermal blankets provide thermal control. Below is a schematic of the SPACEWAY spacecraft bus with some of the major elements identified.

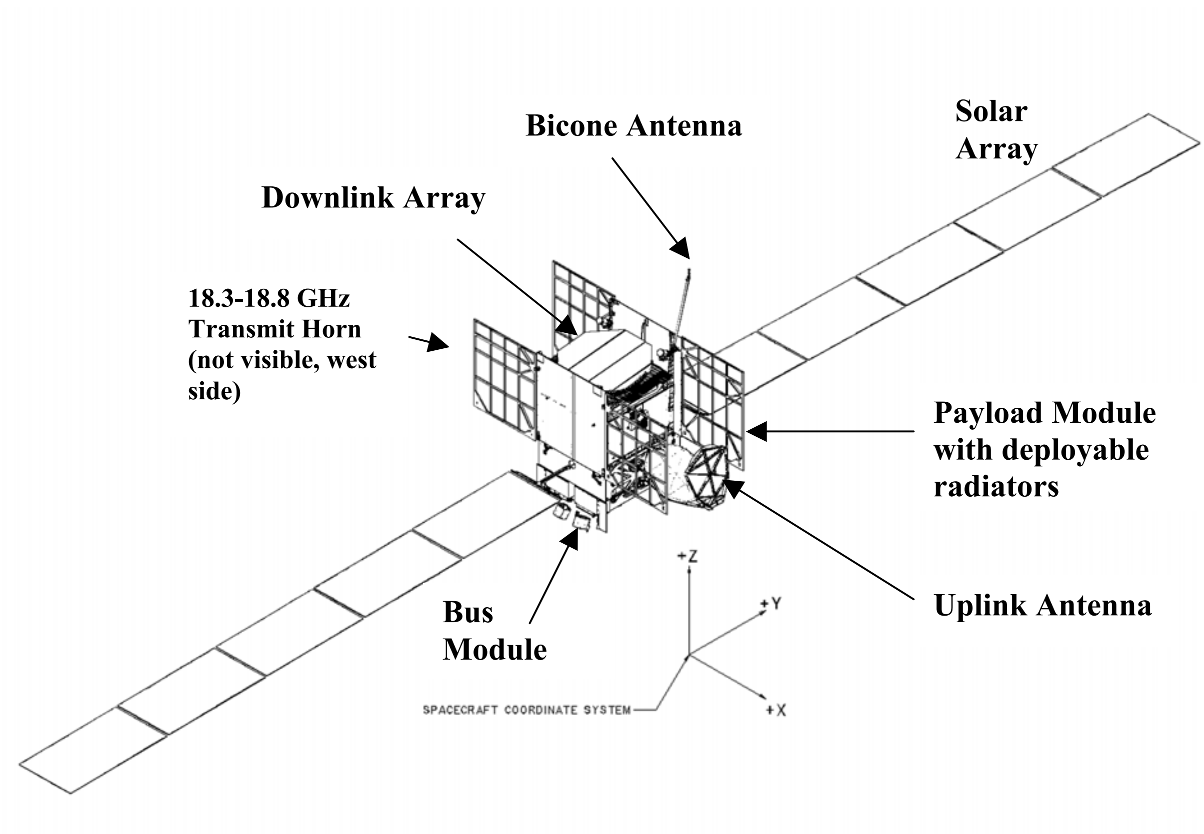

Figure 13-1. SPACEWAY-1 Satellite

14. Common Carrier Status

DIRECTV will operate its satellite on a non-broadcast, non-common carrier basis. DIRECTV may sell and/or lease a portion of its capacity on a non-common carrier basis.

15. Schedule

DIRECTV has already completed most of the construction on this satellite. DIRECTV anticipates that it will complete construction and launch the satellite in the first quarter of 2005, and place it into operation by June 25 2005.

16. Public Interest Considerations

See Section II above.

17. Interference Analysis Demonstrating Two-Degree Spacing Compatibility

Tables A-1 to A-9 of Appendix A demonstrate that the modified satellite design described in this application is compatible with the FCC's two-degree spacing policy and implementing rules, and also show the anticipated margin relative to the satellite downlink PFD coordination threshold. Accordingly, using the requested system modifications, the proposed SPACEWAY-1 satellite will remain in compliance with the relevant FCC technical rules.

Since the Commission licensed the SPACEWAY system in 1997, a number of important developments have been instituted to establish compatibility between new satellite systems. At Ka-band, in order to achieve maximum compatibility between diverse networks, the FCC has established coordination thresholds for earth station EIRP off-axis thresholds and spacecraft PFD in the *18 GHz Order*.[21] These operational restrictions are the outcome of the blanket licensing parameters coordinated by industry for Ka-band earth terminals. The SPACEWAY-1 modification proposal is fully compatible with this aspect of the *18 GHz Order*. For U.S. service from 103° WL, the system complies with the established –118 dBW/m^2/MHz PFD threshold, as well as the PFD limitations established in Section 25.208 of the FCC's rules. This compliance is demonstrated in Appendix A.

The interference studies that are included in this request for modification are performed in conjunction with the end-to-end link performance analyses. Abbreviated link

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[21] *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Station in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite Service Use*, 15 FCC Rcd. 13430 (2000)("*18 GHz Order*").

budgets for all uplink and downlink operating modes are presented in Tables A-1 through A-9 in Appendix A. The uplink data rate modes of 520.8 kbps, 2.083 Mbps and 16.666 Mbps are considered in Tables A-1 to A-3, respectively. The downlink spot beam mode is covered in Table A-4 and the wide-area CONUS coverage mode is given in Table A-5. The DTH non-processor mode is covered in Table A-6 and the various backhaul configurations are covered in Tables A-7 to A-9. In each case, the analysis includes the effects of adjacent satellite interference in evaluating whether the system accommodates the various data rates at acceptable C/(N+I) thresholds.

To properly account for all interference from the adjacent operating satellite systems, the uplink budgets include aggregate interference from earth terminals associated with pairs of satellites at 2, 4, 6, and 8 degrees of orbit separation. The budgets use a level of assumed interference that accounts for the maximum level permissible under the off-axis coordination threshold directive. On the downlink, the adjacent pairs of satellites also at 2, 4, 6, and 8 degrees of orbit separation are each assumed to produce an interference equivalent to that of the PFD coordination threshold value of –118 $dBW/m^2/MHz$. The aggregate adjacent system interference that results from these assumptions is indicated in the link budget worksheet given in Appendix A, Tables A-1 to A-9.

18. Orbital Debris Mitigation

To control orbital debris, DIRECTV will use a design for its satellite and launch vehicle that minimizes the amount of debris released during normal operations. To ensure that its satellite does not become a source of orbital debris, DIRECTV will conduct an analysis to ensure that the probability of collision with any known space-borne objects during its normal operation lifetime is minimal. DIRECTV will also conduct an analysis that demonstrates that no realistic failure modes exist or can lead to an accidental explosion during normal operations or before completion of post-operations disposal. At the end of the operational life of the satellite, DIRECTV will maneuver its spacecraft to a storage orbit with a perigee altitude above its normal operational orbit. DIRECTV will use a maneuver strategy that reduces the risk of leaving any of its spacecraft near an operational orbit. After the spacecraft reaches its final disposal orbit, all on-board sources of stored energy will be depleted or safely secured.

IV. WAIVER PURSUANT TO SECTION 304 OF THE COMMUNICATIONS ACT

In accordance with Section 304 of the Communications Act of 1934, as amended, 47 U.S.C. § 304, DIRECTV 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.

V. CONCLUSION

In summary, the proposed modifications are consistent with the original purpose of the SPACEWAY design and improve the system performance. The current system design together with the proposed modifications is fully compliant with the FCC rules relating to Ka-Band blanket licensing. The modifications fully comport with long-established Commission precedent that allows licensees to modify the design of their licensed systems during the construction phase to take into account state-of-the-art technology and to otherwise optimize their systems. These new design features will improve system performance, flexibility, service quality, overall capacity, and spectrum efficiency, and will create a platform capable of offering more advanced services than ever provided by the commercial space industry anywhere in the world.

For these reasons, DIRECTV submits that the proposed minor modification request is in the public interest and respectfully requests that the Commission expeditiously grant this request.

Respectfully submitted,

THE DIRECTV GROUP, INC.

By: __\s_________________________
Romulo Pontual
Executive Vice President and Chief
Technology Officer

ENGINEERING CERTIFICATION

The undersigned hereby certifies to the Federal Communications Commission as follows:

(i) He is the technically qualified person responsible for the engineering information contained in the foregoing Application for Minor Modification,

(ii) He is familiar with Part 25 of the Commission's Rules, and

(iii) He has either prepared or reviewed the engineering information contained in the foregoing Application for Minor Modification, and it is complete and accurate to the best of his knowledge and belief.

Signed:

/s/

Jack Wengryniuk
Senior Director
DIRECTV Operations Inc.

June 14, 2004

Date

APPENDIX A

SPACEWAY Adjacent System Interference Analysis

Table A-1. SPACEWAY GSO Satellite at 103° West Longitude
Uplink E1/4 Transmission Rate
Link Budget, Adjacent Satellite Interference Analysis, and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Uplink Link Budget (E1/4)	**Rain**	**Clear**	
ST Antenna Diameter	**0.72**	**0.72**	m
Max ST EIRP (peak CW)	**46.90**	**46.90**	dBW
ST EIRP (dBW)	46.80	39.70	dBW
Nominal atmos. and path loss, incl. Wet antenna, wind, gas, cloud, scint.	-215.33	-216.06	dB
Rain Fade	-7.83		dB
Received Isotropic Power, nominal	-176.35	-176.36	dBW
Payload C/(N+I) with Received RIP	8.90	8.89	dB
ACI	16.10	16.10	dB
Spaceway Internal C/(N+I)	8.14	8.13	dB
Single Interference EIRP/MHz	25.00	25.00	dBW/MHz
Interf. Weather Advantage	9.04	1.95	dB
Symbol Rate	0.52	0.52	Msps
Bandwidth Differential	-2.83	-2.83	dB
External System C/I	15.07	15.06	dB
C/(N+I) Total	7.34	7.33	dB
Waveform and DSP Demod Impl. Loss	-1.86	-1.86	dB
Net Available C/(N+I)	5.48	5.47	dB-Hz
Req'd C/(N+I)	5.38	5.38	dB
Uplink System Margin	**0.10**	**0.09**	dB
Compliance with FCC EIRP Threshold			
Norminal Terminal TX Gain		45.40	dBi
Min TX Gain Suppression @ +/- 2 Deg		28.00	dB
Norminal Terminal TX Gain @ +/- 2 Deg		17.40	dBi
TX EIRP @ +/- 2 Deg		18.80	dBW
Carrier Bandwidth		0.65	MHz
TX PFD @ +/- 2 Deg		6.68	dBW/40K Hz
FCC Blanket License PFD Limit @ +/- 2 Deg		11.02	dBW/40K Hz
Margin Against FCC EIRP Threshold		**4.34**	dB

Table A-2. SPACEWAY GSO Satellite at 103° West Longitude Uplink E1 Transmission Rate Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Uplink Link Budget (E1)	**Rain**	**Clear**	
ST Antenna Diameter	**1.30**	**1.30**	m
Max ST EIRP (peak CW)	**53.30**	**53.30**	dBW
ST EIRP (dBW)	53.20	46.25	dBW
Nominal atmos. and path loss, incl. wet antenna, wind, gas, cloud, scint.	-215.33	-216.06	dB
Rain Fade	-7.61		dB
Received Isotropic Power, nominal	-169.73	-169.81	dBW
Payload C/(N+I) with Received RIP	9.22	9.15	dB
ACI	16.00	16.00	dB
Spaceway Internal C/(N+I)	8.40	8.33	dB
Single Interference EIRP/MHz	25.00	25.00	dBW/MHz
Interf. Weather Advantage	8.82	1.95	dB
Symbol Rate	2.08	2.08	Msps
Bandwidth Differential	3.19	3.19	dB
External System C/I	16.19	16.11	dB
C/(N+I) Total	7.73	7.66	dB
Waveform and DSP Demod Impl. Loss	-2.08	-2.08	dB
Net Available C/(N+I)	5.65	5.58	dB-Hz
Req'd C/(N+I)	5.38	5.38	dB
Uplink System Margin	**0.27**	**0.20**	dB
Compliance with FCC EIRP Threshold			
Norminal Terminal TX Gain		49.65	dBi
Min TX Gain Suppression @ +/- 2 Deg		31.00	dB
Norminal Terminal TX Gain @ +/- 2 Deg		18.65	dBi
TX EIRP @ +/- 2 Deg		22.20	dBW
Carrier Bandwidth		2.60	MHz
TX PFD @ +/- 2 Deg		4.06	dBW/40K Hz
FCC Blanket License PFD Limit @ +/- 2 Deg		11.02	dBW/40K Hz
Margin Against FCC EIRP Threshold		**6.96**	dB

Table A-3. SPACEWAY GSO Satellite at 103° West Longitude
Uplink 8E1 Transmission Rate
Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Uplink Link Budget (8E1)	**Rain**	**Clear**	
ST Antenna Diameter	**3.50**	**3.50**	m
Max ST EIRP (peak CW)	**66.50**	**66.50**	dBW
ST EIRP (dBW)	66.40	56.30	dBW
Nominal atoms. and path loss, incl wet antenna, wind, gas, cloud, scint.	-215.33	-216.06	dB
Rain Fade	-11.13		dB
Received Isotropic Power, nominal	-160.06	-159.76	dBW
Payload C/(N+I) with Received RIP	9.61	9.91	dB
ACI	16.50	16.50	dB
Spaceway Internal C/(N+I)	8.81	9.05	dB
Single Interference EIRP/MHz	25.00	25.00	dBW/MHz
Interf. Weather Advantage	12.35	1.95	dB
Symbol Rate	6.11	6.11	Msps
Bandwidth Differential	7.86	7.86	dB
External System C/I	16.83	15.63	dB
C/(N+I) Total	8.17	8.19	dB
Waveform and DSP Demod Impl. Loss	-2.54	-2.54	dB
Net Available C/(N+I)	5.63	5.65	dB-Hz
Req'd C/(N+I)	5.38	5.38	dB
Uplink System Margin	**0.25**	**0.27**	dB
Compliance with FCC EIRP Threshold			
Norminal Terminal TX Gain		58.80	dBi
Min TX Gain Suppression @ +/- 2 Deg		31.00	dB
Norminal Terminal TX Gain @ +/- 2 Deg		27.80	dBi
TX EIRP @ +/- 2 Deg		35.40	dBW
Carrier Bandwidth		20.83	MHz
TX PFD @ +/- 2 Deg		8.23	dBW/40K Hz
FCC Blanket License PFD Limit @ +/- 2 Deg		11.02	dBW/40K Hz
Margin Against FCC EIRP Threshold		**2.79**	dB

Table A-4. SPACEWAY GSO Satellite at 103° West Longitude Point-to-Point Downlink Transmission Rate Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Broadband downlink point-to-point link budget	**Clear Sky**	**Rain Dn**	**Units**
Antenna size	0.74	0.74	m
Max available satellite EIRP	70.2	70.2	dBW
Nominal atmos. and path losses, incl. wet antenna, wind, gas, cloud, scint.	211.6	211.2	dB
Rain attenuation	0.00	9.3	dB
Nominal operating EIRP	60.9	70.2	dBW
Nominal receive isotropic power at user terminal	-150.7	-150.3	dBW
Earth station G/T, actual	17.6	15.1	dB
Receive C/No	95.5	93.4	dB-Hz
Equivalent noise BW	86.0	86.0	dB-Hz
C/N	9.5	7.4	dB
Intrasystem composite interference C/I	15.6	22.0	dB
Intrasystem C/(N+I)	8.5	7.3	dB
Intersystem interference C/I	12.3	22.0	dB
C/(N+I) total	7.1	7.1	dB
Received Ec/(No+Io)	3.8	3.9	dB
E/S equivalent Ec/No threshold	3.85	3.85	dB
Fade margin against link closure for threshold performance	0.0	0.0	dB
GSO coordination			
SPACEWAY terminal effective RIP	-150.7	-150.3	dBW
Isotropic area	47.7	47.7	dB/m^2
SPACEWAY effective PFD	-103.2	-102.9	dB/m^2
Single interference PFD/MHz	-119.0	-119.0	Mcps
Chip rate per beam	800	800	dB
Interference fade/clear loss delta	-0.5	-9.9	dB
E/S aggregate adjacent satellite discrimination C/I intersystem	26.0	26.0	dB
C/I intersystem	-22.0	-22.0	dB
	12.3	22.0	
FCC Compliance			
SPACEWAY PFD (w/o wind, rain, wet antenna loss)	-129.0	-119.0	$dB/m^2/MHz$
COB to EOB differential	0.7	0.7	dB
FCC PFD spec	-118.0	-118.0	$dB/m^2/MHz$
Margin	10.3	0.3	dB
Note: All downlink PTP carriers have the same data rate and modulation parameters			

Table A-5. SPACEWAY GSO Satellite at 103° West Longitude CONUS Downlink Transmission Rate Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Broadband downlink CONUS link budget	**Clear Sky**	**Rain Dn**	**Units**
Antenna size	0.74	0.74	m
Max available satellite EIRP	63.3	63.3	dBW
Nominal atmos. and path losses, incl. wet antenna, wind, gas, cloud, scint.	211.6	211.2	dB
Rain attenuation	0.00	7.6	dB
Nominal operating EIRP	55.7	63.3	dBW
Nominal receive isotropic power at user terminal	-155.9	-155.5	dBW
Earth station G/T, actual	17.2	15.4	dB
Receive C/No	89.9	88.5	dB-Hz
Equivalent noise BW	81.2	81.2	dB-Hz
C/N	8.7	7.2	dB
Intrasystem composite interference C/I	19.3	18.3	dB
Intrasystem C/(N+I)	8.3	6.9	dB
Intersystem interference C/I	11.8	19.9	dB
C/(N+I) total	6.7	6.7	dB
Received Ec/(No+Io)	3.6	3.6	dB
E/S equivalent Ec/No threshold	3.6	3.6	dB
Fade margin against link closure for threshold performance	0.0	0.0	dB
GSO coordination			
SPACEWAY terminal effective RIP	-155.9	-155.5	dBW
Isotropic area	47.4	47.4	dB/m^2
SPACEWAY effective PFD	-108.4	-108.0	dB/m^2
Single interference PFD/MHz	-119.0	-119.0	Mcps
Chip rate per beam	266.66	266.66	dB
Interference fade/clear loss delta	-0.5	-8.2	dB
E/S aggregate adjacent satellite discrimination C/I intersystem	21.2	21.2	dB
C/I intersystem	-22.0	-22.0	dB
	11.8	19.9	
FCC Compliance			
SPACEWAY PFD (w/o wind, rain, wet antenna loss)	-129.4	-121.1	$dB/m^2/MHz$
COB to EOB differential	3.0	3.0	dB
FCC PFD spec	-118.0	-118.0	$dB/m^2/MHz$
Margin	8.4	0.1	dB

Table A-6. SPACEWAY Satellite at 103° West Longitude DTH Link Budget, Adjacent Satellite Interference Analysis, and Compliance with FCC Off-Axis Blanket Licensing Thresholds

		Clear Sky	Rain Dn	Notes
Uplink C/N (thermal), dB	Transmit power, dBW	5.1	10.2	
Los Angeles	Transmit losses, dB	-2.0	-2.0	
f = 30 GHz	Ground antenna gain, dB	66.8	66.8	9-meter
	Antenna pointing loss, dB	-0.5	-0.5	
	Free space loss, dB	-213.5	-213.5	
	Atmospheric loss, dB	-1.1	-1.1	
	Uplink rain loss, dB	0.0	-5.0	
	Satellite G/T, dB/K	15.8	15.8	
	Bandwidth, dB-Hz	-73.0	-73.0	20 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Uplink C/N		**26.3**	**26.3**	
Downlink C/N (thermal),dB	Satellite EIRP, dBW/24 MHz	58.4	58.4	-118 dBW/m^2/MHz
New York	Free space loss, dB	-210.1	-210.1	
f = 20 GHz	Atmospheric loss, dB	-1.0	-1.0	
	Downlink rain loss, dB	0.0	-7.6	99.90%
	Rain temp increase, dB	0.0	-3.9	
	Rcv. antenna pointing loss, dB	-0.5	-0.5	
	Ground G/T, dB/K	19.4	19.4	65 cm
	Bandwidth, dB-Hz	-73.0	-73.0	
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Downlink C/N		**21.8**	**10.4**	
		Clear Sky	**Rain Dn**	
Totals	Uplink C/N (thermal), dB	26.3	26.3	
	Downlink C/N (thermal), dB	21.8	10.4	
	x-pol interference, dB	99.0	99.0	
	Aggregate C/I from ASI*	16.6	16.6	
	Aggregate C/I from TX E/S	26.6	26.6	
	Total C/(N+I), dB	**14.8**	**9.3**	
	Required C/(N+I), dB	**9.0**	**9.0**	8PSK 3/4
	Margin, dB	**5.8**	**0.3**	

* Based on -118 dBW/m^2/MHz from satellites at +/- 2, 4, 6 and 8 deg. Off-axis = 29-25log(theta) + 8 dB

Table A-6 (Cont.) SPACEWAY GSO Satellite at 103° West Longitude DTH Link Budget, Adjacent Satellite Interference Analysis, and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Off-Axis EIRP Compliance				
Max TX power (minus losses) = 3.1 dBW/24 MHz = -24.7 dBW/40 kHz				
Feeder-link antenna conforms to Section 25.209				
Degrees off-axis	**§25.209 Allowable Antenna Gain, dB**	**Max SPACEWAY EIRP, dBW/40 kHz**	**§25.138 Allowable Off-Axis EIRP, dBW/40 kHz**	**Margin, dB**
2.0	21.5	-3.2	11.0	14.2
4.0	13.9	--10.8	3.4	14.2
6.0	9.5	-15.2	-1.0	14.2
8.0	6.4	-18.3	-2.6	15.7

Table A-7. SPACEWAY GSO Satellite at 103° West Longitude 24 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

		Clear Sky	Rain Dn	Notes
Uplink C/N (thermal), dB	Transmit power, dBW	10.2	15.2	
Castle Rock	Transmit losses, dB	-2.0	-2.0	
f = 29.5 GHz	Ground antenna gain, dB	66.7	66.7	9-meter
	Antenna pointing loss, dB	-0.5	-0.5	
	Free space loss, dB	-213.4	-213.4	
	Atmospheric loss, dB	-1.1	-1.1	
	Uplink rain loss, dB	0.0	-5.0	
	Satellite G/T, dB/K	13.1	13.1	
	Bandwidth, dB-Hz	-73.0	-73.0	20 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Uplink C/N		**28.6**	**28.6**	
Downlink C/N (thermal),dB	Satellite EIRP, dBW/24 MHz	24.0	24.0	OBO = 3 dB; PFD = -152.3 dBW/m^2/MHz
Los Angeles	Free space loss, dB	-209.3	-209.3	
f = 18.5 GHz	Atmospheric loss, dB	-1.0	-1.0	
	Downlink rain loss, dB	0.0	-1.8	99.80%
	Rain temp increase, dB	0.0	-1.8	
	Rcv. antenna pointing loss, dB	-0.5	-0.5	
	Ground G/T, dB/K	39.3	39.3	9-meter
	Bandwidth, dB-Hz	-73.0	-73.0	20 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Downlink C/N		**8.2**	**4.6**	
		Clear Sky	**Rain Dn**	
Totals	Uplink C/N (thermal), dB	28.6	28.6	
	Downlink C/N (thermal), dB	8.2	4.6	
	x-pol interference, dB	99.0	99.0	
	Aggregate C/I from ASI*	10.8	10.8	
	Aggregate C/I from TX E/S	31.6	31.6	
	Total C/(N+I), dB	**6.2**	**3.6**	
	Required C/(N+I), dB	**1.9**	**1.9**	QPSK 1/2
	Margin, dB	**4.3**	**1.7**	

* Based on -118 dBW/m^2/MHz from satellites at +/- 2, 4, 6 and 8 deg. Off-axis = 29-25log(theta) + 8 dB

Table A-7 (cont.) SPACEWAY GSO Satellite at 103° West Longitude
24 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

Off-Axis EIRP Compliance				
Max TX power (minus losses) = 8.2 dBW/24 MHz = -19.6 dBW/40 kHz				
Feeder-link antenna conforms to Section 25.209				
Degrees off-axis	**§25.209 Allowable Antenna Gain, dB**	**Max SPACEWAY EIRP, dBW/40 kHz**	**§25.138 Allowable Off-Axis EIRP, dBW/40 kHz**	**Margin, dB**
2.0	21.5	1.9	11.0	9.1
4.0	13.9	-5.7	3.4	9.2
6.0	9.5	-10.1	-1.0	9.1
8.0	6.4	-13.2	-2.6	10.6

Table A-8. SPACEWAY GSO Satellite at 103° West Longitude
36 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis, and Compliance with FCC Off-Axis Blanket Licensing Thresholds

		Clear Sky	Rain Dn	Notes
Uplink C/N (thermal), dB	Transmit power, dBW	12.7	17.7	
Castle Rock	Transmit losses, dB	-2.0	-2.0	
f = 29.5 GHz	Ground antenna gain, dB	66.7	66.7	9-meter
	Antenna pointing loss, dB	-0.5	-0.5	
	Free space loss, dB	-213.4	-213.4	
	Atmospheric loss, dB	-1.1	-1.1	
	Uplink rain loss, dB	0.0	-5.0	
	Satellite G/T, dB/K	13.1	13.1	
	Bandwidth, dB-Hz	-75.5	-75.5	30 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Uplink C/N		**28.6**	**28.6**	
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	27.0	27.0	OBO = 0 dB; PFD = -151.1 dBW/m^2/MHz
Los Angeles	Free space loss, dB	-209.3	-209.3	
f = 18.5 GHz	Atmospheric loss, dB	-1.0	-1.0	
	Downlink rain loss, dB	0.0	-1.8	99.80%
	Rain temp increase, dB	0.0	-1.8	
	Rcv. antenna pointing loss, dB	-0.5	-0.5	
	Ground G/T, dB/K	39.3	39.3	9-meter
	Bandwidth, dB-Hz	-75.5	-75.5	30 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Downlink C/N		**8.7**	**5.1**	
		Clear Sky	**Rain Dn**	
Totals	Uplink C/N (thermal), dB	28.6	28.6	
	Downlink C/N (thermal), dB	8.7	5.1	
	x-pol interference, dB	99.0	99.0	
	Aggregate C/I from ASI*	12.0	12.0	
	Aggregate C/I from TX E/S	32.3	32.3	
	Total C/(N+I), dB	**7.0**	**4.3**	
	Required C/(N+I), dB	**1.9**	**1.9**	QPSK 1/2
	Margin, dB	**5.1**	**2.4**	

* Based on -118 dBW/m^2/MHz from satellites at +/- 2, 4, 6 and 8 deg. Off-axis = 29-25log(theta) + 8 dB

Table A-8 (cont.) SPACEWAY GSO Satellite at 103° West Longitude
36 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis, and Compliance with FCC Off-Axis Blanket Licensing Thresholds

B Band Backhaul Mode				
Max TX power (minus losses) = 10.7 dBW/36 MHz = -18.8 dBW/40 kHz				
Feeder-link antenna conforms to Section 25.209				
Degrees off-axis	**§25.209 Allowable Antenna Gain, dB**	**Max Spaceway EIRP, dBW/40 kHz**	**§25.138 Allowable Off-Axis EIRP, dBW/40 kHz**	**Margin, dB**
2.0	21.5	2.7	11.0	8.3
4.0	13.9	-4.9	3.4	8.3
6.0	9.5	-9.3	-1.0	8.3
8.0	6.4	-12.4	-2.6	19.8

Table A-9. SPACEWAY GSO Satellite at 103° West Longitude 54 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

		Clear Sky	Rain Dn	Notes
Uplink C/N (thermal), dB	Transmit power, dBW	13.7	18.7	
Castle Rock	Transmit losses, dB	-2.0	-2.0	
f = 29.5 GHz	Ground antenna gain, dB	66.7	66.7	9-meter
	Antenna pointing loss, dB	-0.5	-0.5	
	Free space loss, dB	-213.4	-213.4	
	Atmospheric loss, dB	-1.1	-1.1	
	Uplink rain loss, dB	0.0	-5.0	
	Satellite G/T, dB/K	13.1	13.1	
	Bandwidth, dB-Hz	-76.5	-76.5	45 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Uplink C/N		**28.6**	**28.6**	
Downlink C/N (thermal),dB	Satellite EIRP, dBW/54 MHz	27.0	27.0	OBO = 0 dB; PFD = -152.8 dBW/m^2/MHz
Los Angeles	Free space loss, dB	-209.3	-209.3	
f = 18.5 GHz	Atmospheric loss, dB	-1.0	-1.0	
	Downlink rain loss, dB	0.0	-1.8	99.80%
	Rain temp increase, dB	0.0	-1.8	
	Rcv. antenna pointing loss, dB	-0.5	-0.5	
	Ground G/T, dB/K	39.3	39.3	9-meter
	Bandwidth, dB-Hz	-76.5	-76.5	45 Msps
	Boltzmann's constant, dBW/Hz K	228.6	228.6	
Total Downlink C/N		**7.7**	**4.1**	
		Clear Sky	**Rain Dn**	
Totals	Uplink C/N (thermal), dB	28.6	28.6	
	Downlink C/N (thermal), dB	7.7	4.1	
	x-pol interference, dB	99.0	99.0	
	Aggregate C/I from ASI*	10.3	10.3	
	Aggregate C/I from TX E/S	31.5	31.5	
	Total C/(N+I), dB	**5.7**	**3.1**	
	Required C/(N+I), dB	**1.9**	**1.9**	QPSK 1/2
	Margin, dB	**3.8**	**1.2**	

* Based on -118 dBW/m^2/MHz from satellites at +/- 2, 4, 6 and 8 deg. Off-axis = 29-25log(theta) + 8 dB

Table A-9 (cont.) SPACEWAY GSO Satellite at 103° West Longitude
54 MHz Channel Backhaul Link Budget, Adjacent Satellite Interference Analysis and Compliance with FCC Off-Axis Blanket Licensing Thresholds

B Band Backhaul Mode				
Max TX power (minus losses) = 11.7 dBW/54 MHz = -19.6 dBW/40 kHz				
Feeder-link antenna conforms to Section 25.209				
Degrees off-axis	**§25.209 Allowable Antenna Gain, dB**	**Max Spaceway EIRP, dBW/40 kHz**	**§25.138 Allowable Off-Axis EIRP, dBW/40 kHz**	**Margin, dB**
2.0	21.5	1.9	11.0	9.1
4.0	13.9	-5.7	3.4	9.2
6.0	9.5	-10.1	-1.0	9.1
8.0	6.4	-13.2	-2.6	10.6

APPENDIX B

Satellite Service Area Definitions and

Example Spot and Area Coverage Beam Patterns

Section B1. Uplink and Downlink Service Area Definition

Figure B-1.1. Example 0.5° uplink beam coverage from 103° WL orbital position. Beams may be placed anywhere within the Field of View.

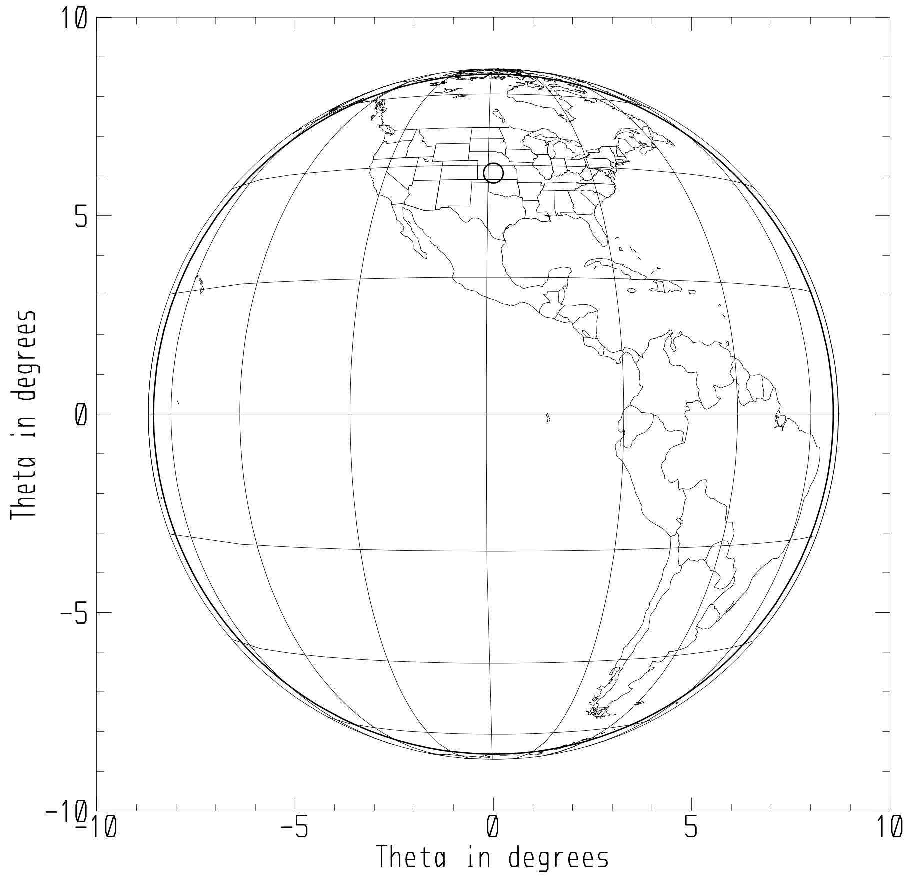
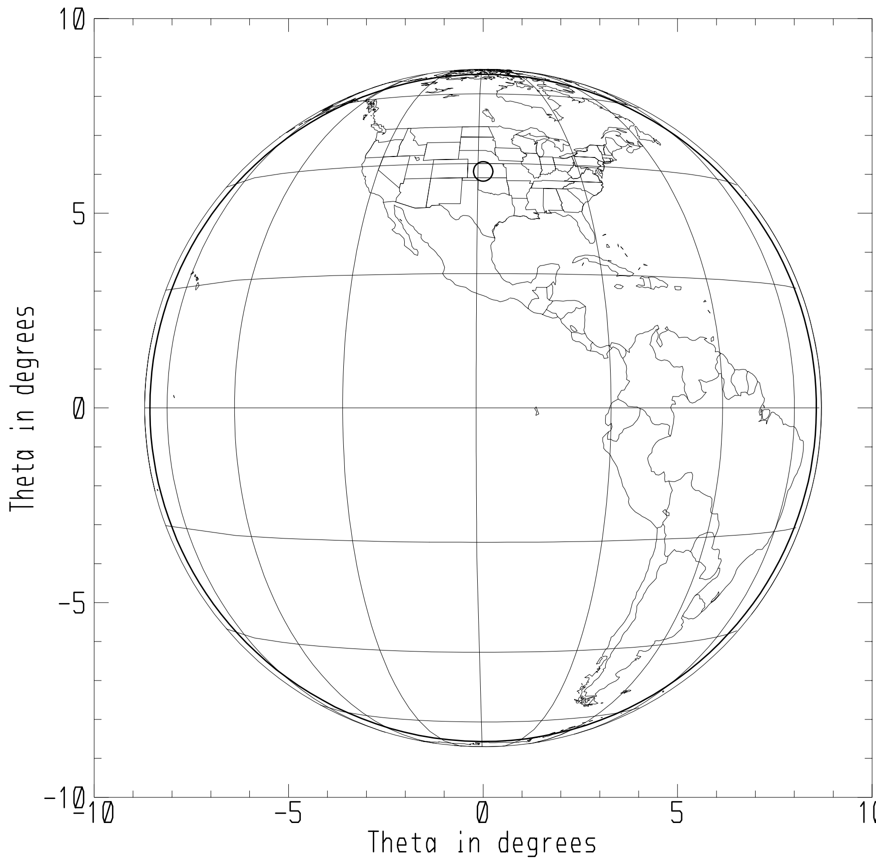


Figure B-1.2. Example 0.5° downlink spot beam coverage from 103° WL orbital position.
Beams may be placed anywhere within the Field of View.



Section B2 Uplink and Downlink Spot Beam Pattern Characteristics

Figure B-2.1. Uplink spot beam antenna directivity contours with peak directivity of 50.1 dBi

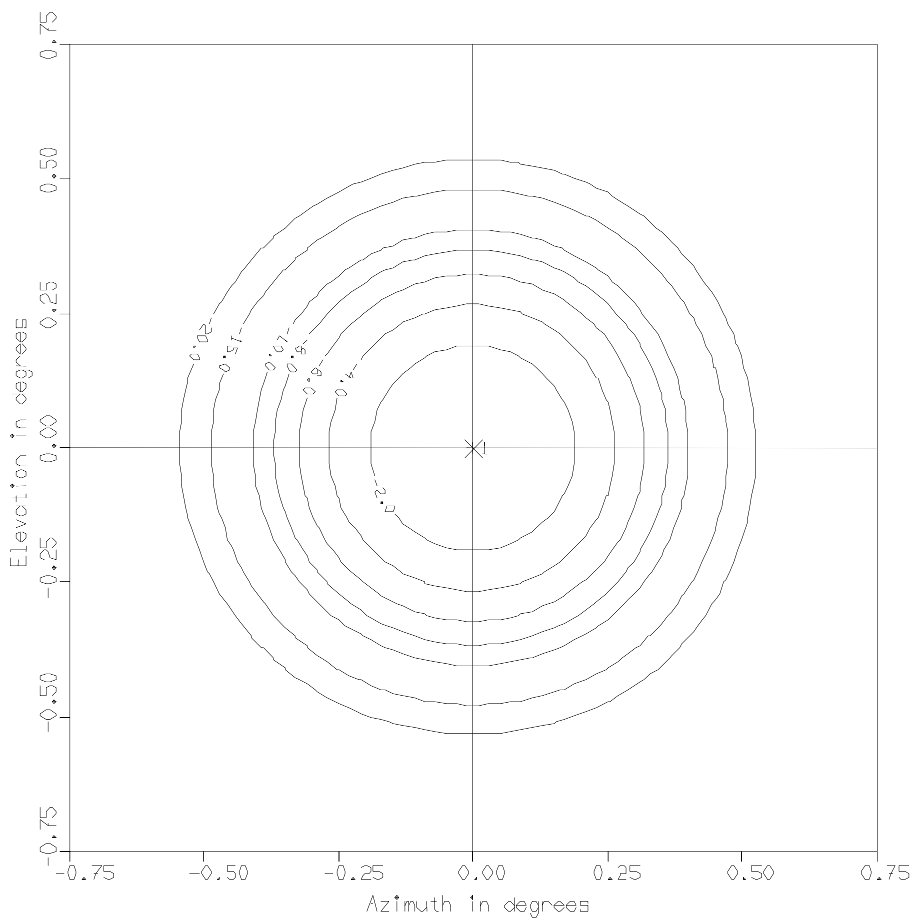
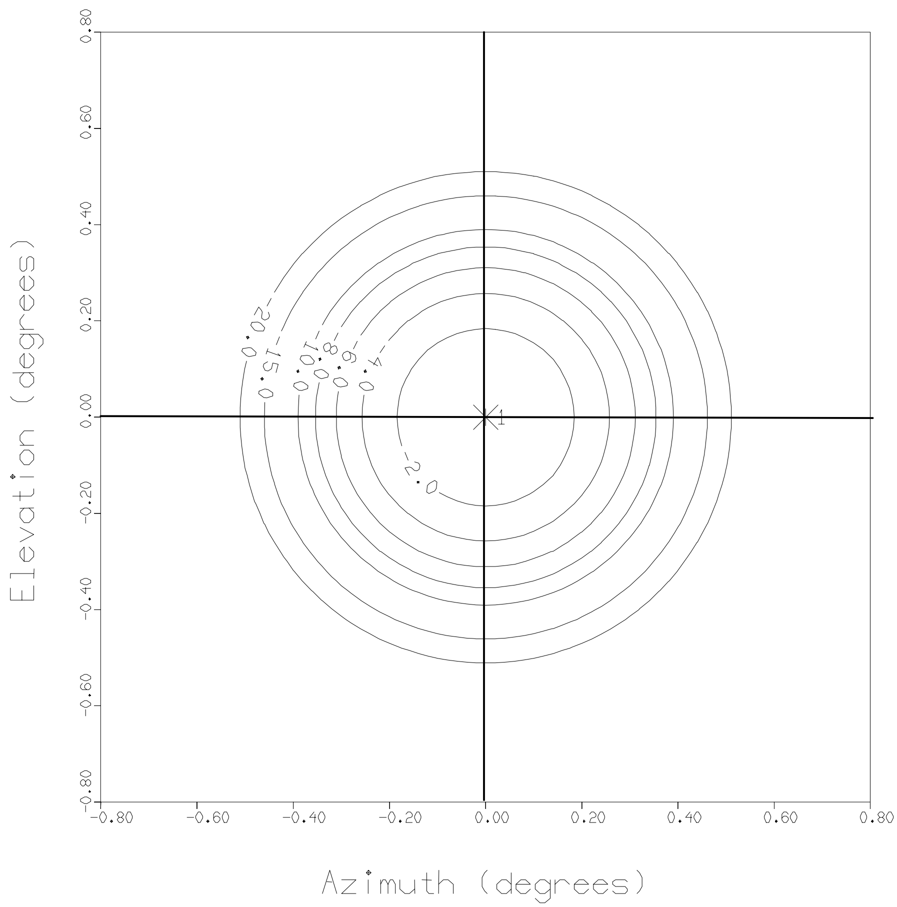
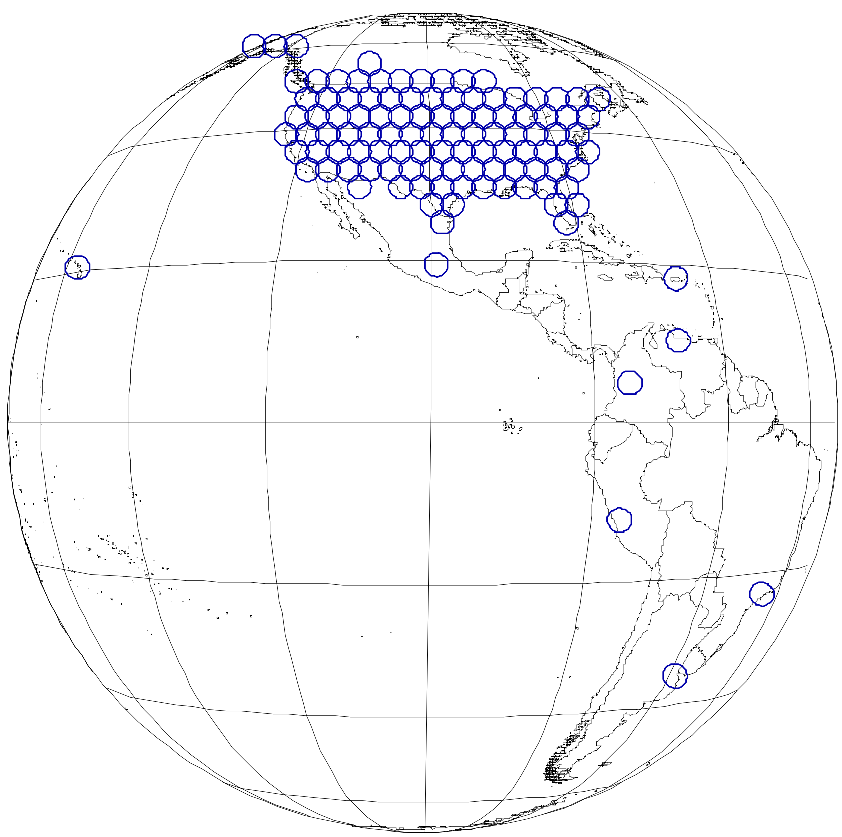


Figure B-2.2. Downlink spot beam antenna directivity contours with peak directivity of 51.5 dBi



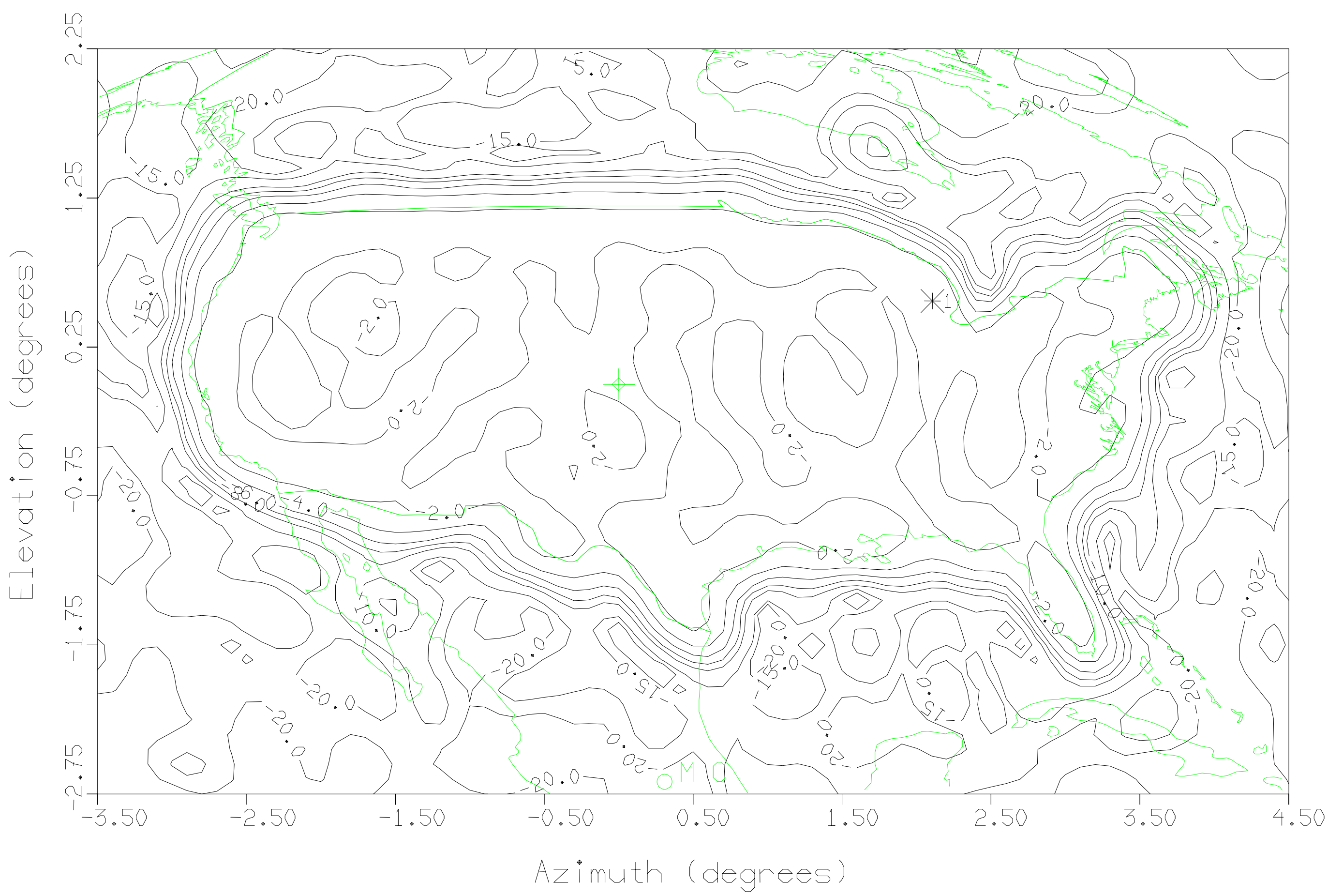
Section B3 Representative Point to Point Uplink and Downlink Beam Groupings for Different Orbit Locations

Figure B-3.1. Example Implementation of Beam Use at 103° WL. Spot Beam Service Area Designations are for Both Uplink and Downlink – Complete Satellite Field of View



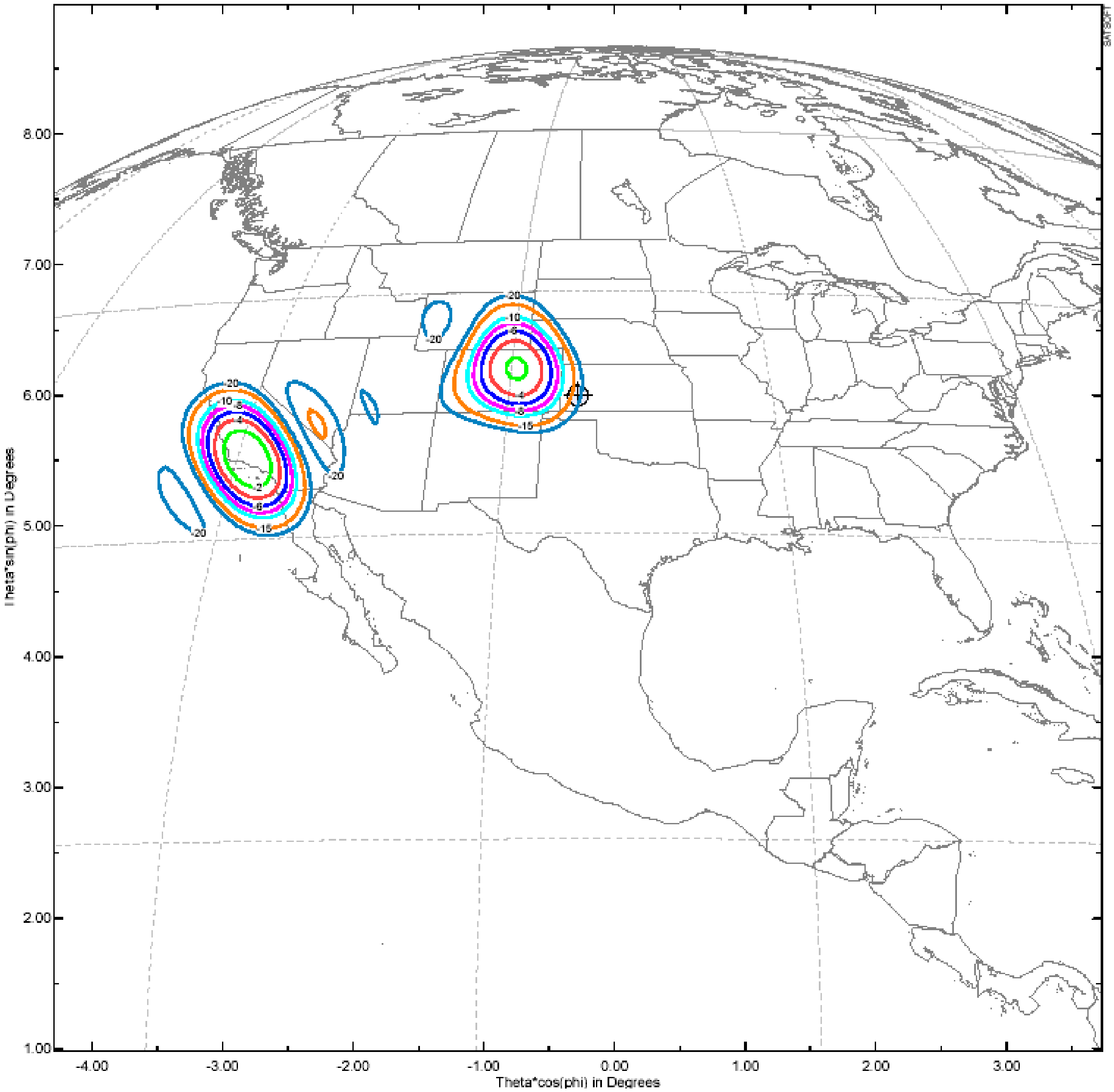
Section B4 Downlink Area Coverage for Different Orbit Locations

Figure B-4.1. Example CONUS coverage from 103° WL



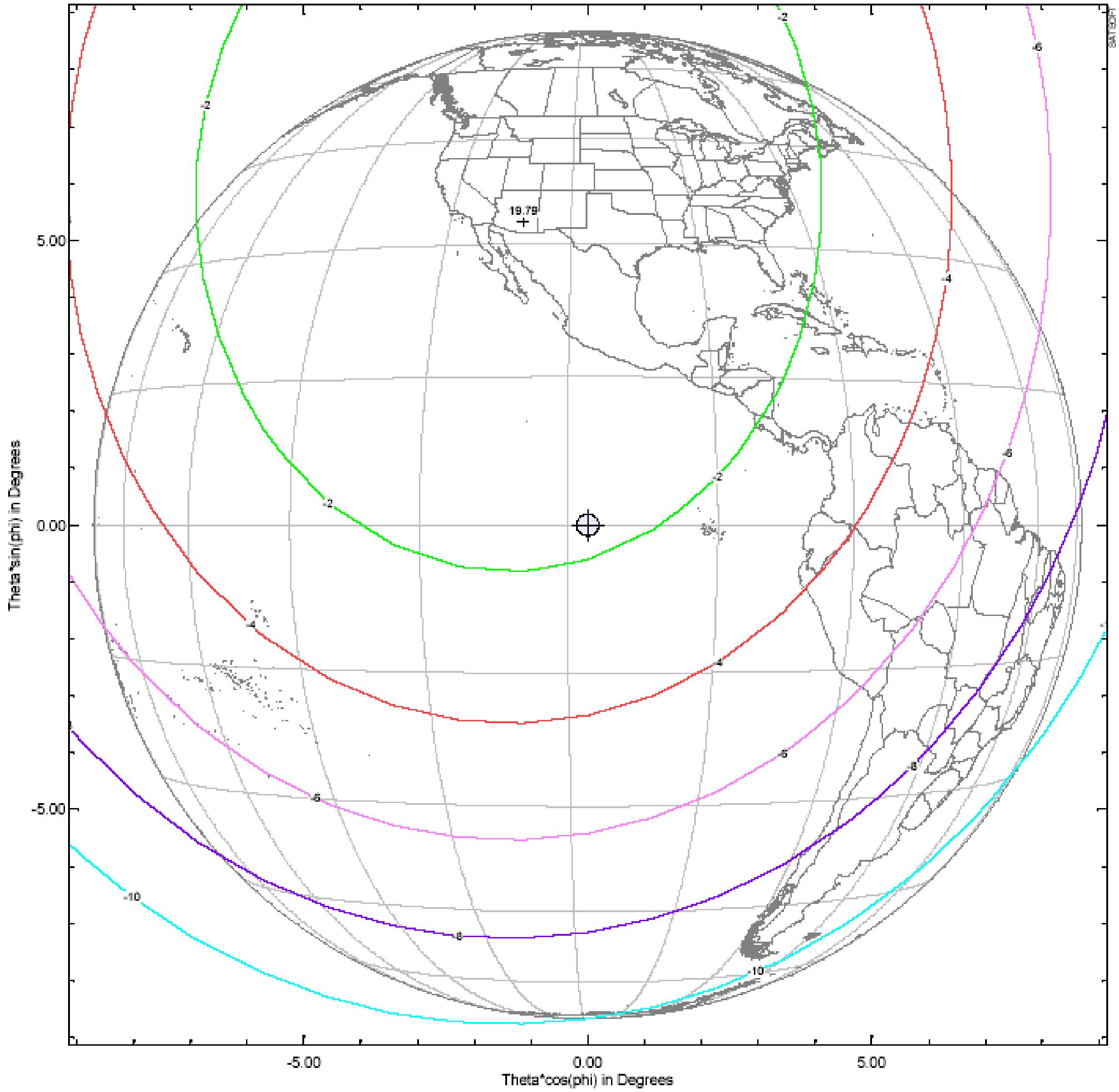
Section B5 Uplink Antenna Coverage for 28.35-28.6 GHz Frequency Band and for Telecommand

Figure B-5.1. Antenna Contour for 28.35-28.6 GHz Receive Antenna and for Command



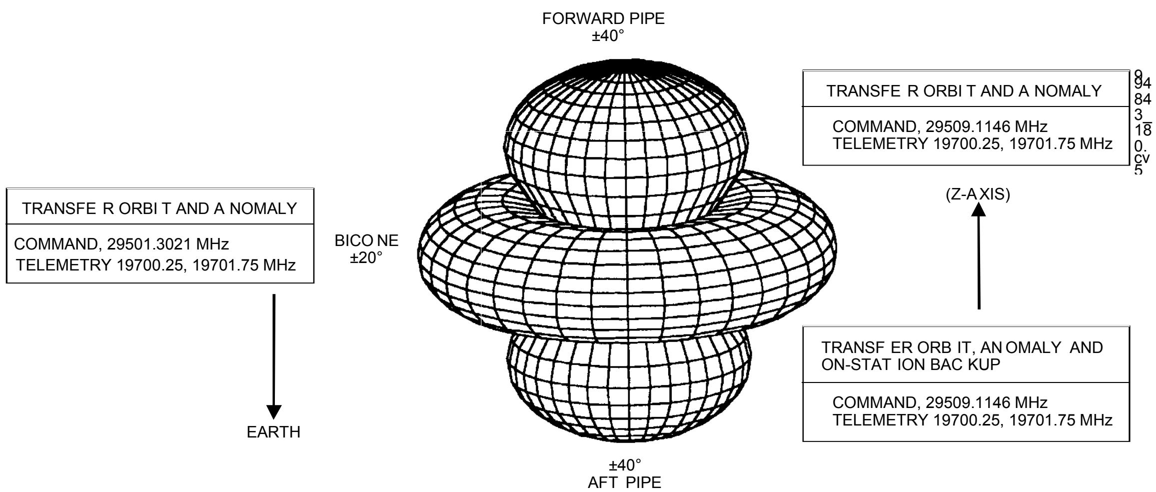
Section B6 Downlink Antenna Coverage for 18.3-18.8 GHz Frequency Band and Telemetry

Figure B-6.1. Antenna Contour for 18.3-18.8 GHz Transmit Antenna and Telemetry



Section B7 TT&C Bicone and Horn Antenna Coverage

Figure B.7-1. TT&C Bicone and Horn Antenna Coverage



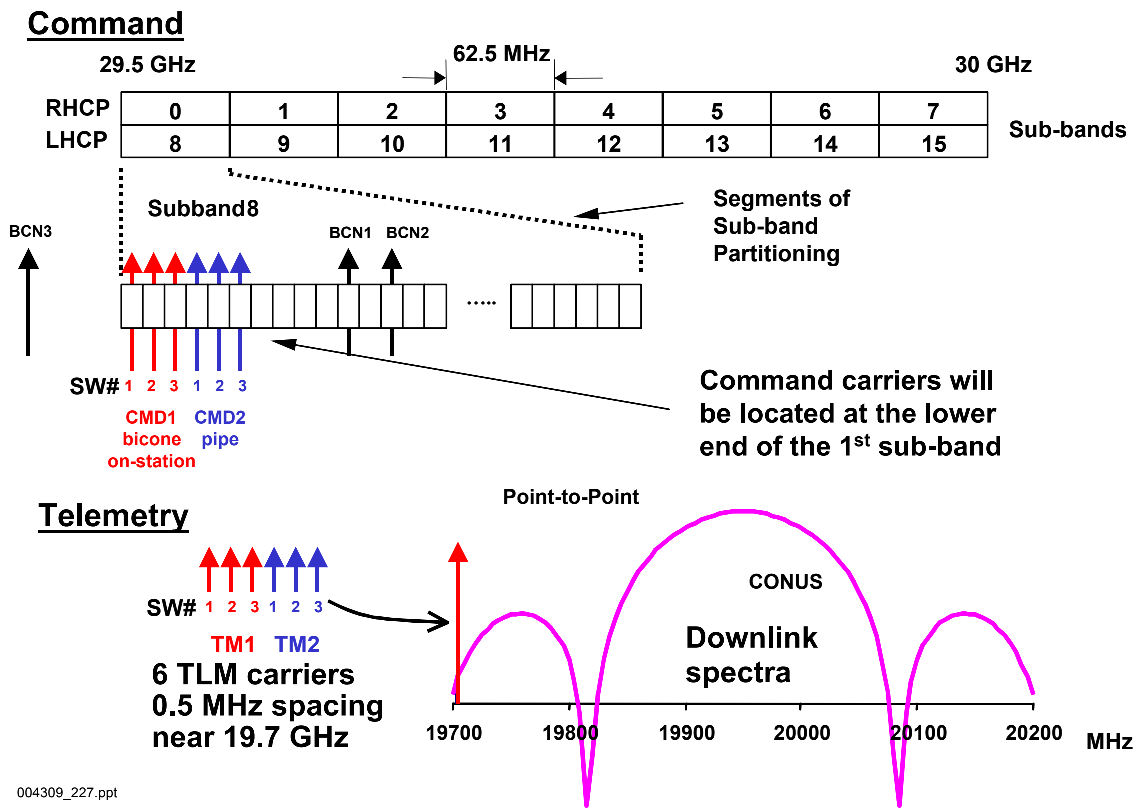
Note: Command and telemetry frequencies are representative only. Specific frequencies may vary from mission to mission.

APPENDIX C

TT&C Frequency Plan, Links and Interference Analyses

Section C1 TT&C Frequency Plan

Figure C-1.1. TT&C Frequency Plan



Section C2 Representative Link Performance

Table C-2.1. Example On-Station Command Link Performance

	Units	U/L Antenna Rain	U/L Antenna Clear	Forward Pipe Rain	Forward Pipe Clear	Aft Pipe Rain	Aft Pipe Clear	Bicone Rain	Bicone Clear
Frequency	GHz	29.50	29.50	29.50	29.50	29.50	29.50	29.50	29.50
Elevation Angle	deg.	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
Slant Range	km	37511	37511	37511	37511	37511	37511	37511	37511
Uplink Availability	**%**	**99.97**		**99.98**		**99.97**		**99.95**	
Required GS EIRP	dBWi	45.27	39.19	89.34	80.69	91.27	85.19	91.87	88.19
Available GS EIRP	dBWi	92.70	92.70	92.70	92.70	92.70	92.70	92.70	92.70
EIRP Margin	**dB**	**47.43**	**53.51**	**3.36**	**12.01**	**1.43**	**7.51**	**0.83**	**4.51**
Free Space loss	dB	-213.32	-213.32	-213.32	-213.32	-213.32	-213.32	-213.32	-213.32
Gaseous Att	dB	-0.44	-0.37	-0.44	-0.37	-0.44	-0.37	-0.44	-0.37
Cloud Att	dB	-0.79		-0.79		-0.79		-0.79	
Rain Fade	dB	-7.73		-10.29		-7.73		-5.32	
Total Atmospheric loss	dB	-8.95	-0.37	-11.52	-0.37	-8.95	-0.37	-6.55	-0.37
Rain Fade		-8.58		-11.15		-8.58		-6.18	
Min Rx Isotropic Power (RIP)	dBWi	-177.00	-174.50	-135.50	-133.00	-131.00	-128.50	-128.00	-125.50
Max Rx Isotropic Power (RIP)	dBWi	-172.00		-130.50		-126.00		-123.00	
Polarization Loss	dB	-0.01	-0.01	-0.22	-0.22	-0.22	-0.22	-0.10	-0.10
Rec Ant Gain	dB	47.63	47.63	5.00	5.00	5.00	5.00	-0.70	-0.70
Pointing Loss	dB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Min Rec Signal Level	dBW	-129.38	-126.88	-130.72	-128.22	-126.22	-123.72	-128.80	-126.30
S/C NF including CR	dB	11.01	11.01	11.06	11.06	15.74	15.74	14.15	14.15
S/C Gain up to CR	dB	-4.56	-4.56	-8.06	-8.06	-12.74	-12.74	-11.15	-11.15
Antenna Temperature	K	290.00	290.00	290.00	290.00	290.00	290.00	290.00	290.00
System Noise Temp	dBK	35.64	35.64	35.69	35.69	40.37	40.37	38.77	38.77
Noise Power Density No	dBW/Hz	-192.96	-192.96	-192.91	-192.91	-188.23	-188.23	-189.83	-189.83
Io On-Station	dBW/Hz	-197.14	-197.14	-237.67	-237.67	-237.67	-237.67	-224.66	-224.66
Total No+Io	dBW/Hz	-191.56	-191.56	-192.91	-192.91	-188.23	-188.23	-189.83	-189.83
C/No	dB-Hz	63.58	66.08	62.19	64.69	62.01	64.51	61.03	63.53
C/(No+Io)	dB-Hz	62.18	64.68	62.19	64.69	62.01	64.51	61.03	63.53
Required C/(No+Io)	**dB-Hz**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**
Margin	**dB**	**1.18**	**3.68**	**1.19**	**3.69**	**1.01**	**3.51**	**0.03**	**2.53**

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Table C-2.2. Example Transfer Orbit Command Link Performance

Castle Rock	Units	Fwd Pipe Rain	Fwd Pipe Clear	Aft Pipe Rain	Aft Pipe Clear	Bicone Rain	Bicone Clear
Frequency	GHz	29.50	29.50	29.50	29.50	29.50	29.50
Elevation Angle	deg.	20.0	20.0	20.0	20.0	20.0	20.0
Slant Range	km	62047	62047	62047	62047	62047	62047
Uplink Availability	**%**	**99.70**		**99.70**		**99.70**	
GS EIRP (dBW)	dBW	87.70	87.70	92.20	92.20	95.20	95.20
Maximum GS EIRP	dBWi	92.70	92.70	92.70	92.70	92.70	92.70
EIRP Margin	**dB**	**5.00**	**5.00**	**0.50**	**0.50**	**-2.50**	**-2.50**
Free Space loss	dB	-217.69	-217.69	-217.69	-217.69	-217.69	-217.69
Gaseous Att	dB	-0.88	-0.75	-0.88	-0.75	-0.88	-0.75
Cloud Att	dB	-1.59		-1.59		-1.59	
Rain Fade	dB	-3.04		-3.04		-3.04	
Total Atmospheric loss	dB	-5.51	-0.75	-5.51	-0.75	-5.51	-0.75
Rain Fade		-4.76		-4.76		-4.76	
Min Rx Isotropic Power (RIP)	dBWi	-135.50	-130.74	-131.00	-126.24	-128.00	-123.24
Polarization Loss	dB	-0.22	-0.22	-0.22	-0.22	-0.10	-0.10
Rec Ant Gain	dB	5.00	5.00	5.00	5.00	-0.70	-0.70
Pointing Loss	dB	0.00	0.00	0.00	0.00	0.00	0.00
Min Rec Signal Level	dBW	-130.72	-125.96	-126.22	-121.46	-128.80	-124.04
S/C NF including CR	dB	11.06	11.06	15.74	15.74	14.15	14.15
S/C Gain up to CR	dB	-8.06	-8.06	-12.74	-12.74	-11.15	-11.15
Antenna Temperature	K	290.00	290.00	290.00	290.00	290.00	290.00
System Noise Temp	dBK	35.69	35.69	40.37	40.37	38.77	38.77
Noise Power Density No	dBW/Hz	-192.91	-192.91	-188.23	-188.23	-189.83	-189.83
C/No	dB-Hz	62.19	66.95	62.01	66.77	61.03	65.79
Required C/No	**dB-Hz**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**	**61.00**
Margin	**dB**	**1.19**	**5.95**	**1.01**	**5.77**	**0.03**	**4.79**

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Table C-2.3. Example On-Station Telemetry Link Performance

		Telemetry Horn		Fwd Pipe		Aft Pipe		Bicone	
	Units	Rain	Clear	Rain	Clear	Rain	Clear	Rain	Clear
Frequency	GHz	19.70	19.70	19.70	19.70	19.70	19.70	19.70	19.70
Elevation Angle	deg.	43.61	43.61	43.61	43.61	43.61	43.61	43.61	43.61
Slant Range	km	37511	37511	37511	37511	37511	37511	37511	37511
Downlink Availability	**%**	**99.95**		**99.95**		**99.95**		**99.95**	
RF power (peak CW)	W	50	50	15	15	15	15	15	15
Xmtr Power (peak CW)	dBW	16.99	16.99	11.76	11.76	11.76	11.76	11.76	11.76
2 Carrier Output Back-off	**dBW**	**-4.20**	**-4.20**						
Output Loss	dB	-3.05	-3.05	-7.47	-7.47	-8.85	-8.85	-5.24	-5.24
S/C TLM Ant Directivity	dB	22.30	22.30	5.00	5.00	5.00	5.00	-0.70	-0.70
S/C EIRP (dBW)	dBW	32.04	32.04	9.29	9.29	7.91	7.91	5.82	5.82
Required EIRP (dBW)	dBW	31.50	31.50	8.80	8.80	7.40	7.40	5.30	5.30
Margin (dBW)	dBW	0.54	0.54	0.49	0.49	0.51	0.51	0.52	0.52
Free Space loss	dB	-209.81	-209.81	-209.81	-209.81	-209.81	-209.81	-209.81	-209.81
Gaseous Att	dB	-0.46	-0.37	-0.46	-0.37	-0.46	-0.37	-0.46	-0.37
Cloud Att	dB	-0.36		-0.36		-0.36		-0.36	
Rain Fade	dB	-2.57		-2.57		-2.57		-2.57	
Total Atmospheric loss	dB	-3.39	-0.37	-3.39	-0.37	-3.39	-0.37	-3.39	-0.37
Rain fade		-3.02		-3.02		-3.02		-3.02	
Min Rx Isotropic Power (RIP)	dBW	-181.70	-178.69	-204.40	-201.39	-205.80	-202.79	-207.90	-204.89
Polarization Loss	dB	-0.02	-0.02	-0.22	-0.22	-0.22	-0.22	-0.10	-0.10
Pointing Loss	dB	-0.50	-0.50	0.00	0.00	0.00	0.00	0.00	0.00
Ground Station G/T	dB/K	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00
Receiver Temperature	K	225	225	225	225	225	225	225	225
Background Temperature	K	152	23	152	23	152	23	152	23
G/T Degradation	dB	-1.81	0.00	-1.81	0.00	-1.81	0.00	-1.81	0.00
Boltzmann's Constant	dBW/kHz	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60
C/No Received	dB-Hz	82.56	87.39	60.16	64.99	58.76	63.59	56.78	61.61
Data demodulation at BER=1E-6									
PCM Data Rate	kbps	4	4	4	4	4	4	4	4
Required C/No (single mode)	dB-Hz	**50.93**	**50.93**	**50.93**	**50.93**	**50.93**	**50.93**	**50.93**	**50.93**
Required C/No (SIMO mode)	**dB-Hz**	**56.62**	**56.62**	**56.62**	**56.62**	**56.62**	**56.62**	**56.62**	**56.62**
Margin* (single mode)	dB	**31.63**	**36.46**	**9.23**	**14.06**	**7.83**	**12.66**	**5.85**	**10.68**
Margin* (SIMO mode)	**dB**	**25.94**	**30.77**	**3.54**	**8.37**	**2.14**	**6.97**	**0.16**	**4.99**

With interference

		Telemetry Horn Rain	Telemetry Horn Clear	Fwd Pipe Rain	Fwd Pipe Clear
C/Io	dB-Hz	61.42	61.42	38.72	38.72
Total C/(No+Io)	**dB-Hz**	**61.39**	**61.41**	**38.69**	**38.71**
Data demodulation at BER=1E-6					
PCM Data Rate	kbps	4	4	4	4
Required C/No (single mode)	dB-Hz	**50.93**	**50.93**	**50.93**	**50.93**
Required C/No (SIMO mode)	**dB-Hz**	**56.62**	**56.62**	**56.62**	**56.62**
Margin* (single mode)	dB	**10.45**	**10.48**	**-12.24**	**-12.22**
Margin* (SIMO mode)	**dB**	**4.76**	**4.79**	**-17.93**	**-17.91**

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Table C-2.4. Example Transfer Orbit Telemetry Link Performance

		Fwd Pipe		Aft Pipe		Bicone	
	Units	Rain	Clear	Rain	Clear	Rain	Clear
Frequency	GHz	19.70	19.70	19.70	19.70	19.70	19.70
Elevation Angle	deg.	20.00	20.00	20.00	20.00	20.00	20.00
Slant Range	km	62047	62047	62047	62047	62047	62047
Downlink Availability	**%**	**99.90**		**99.90**		**99.90**	
RF power (peak CW)	W	15	15	15	15	15	15
Xmtr Power (peak CW)	dBW	11.76	11.76	11.76	11.76	11.76	11.76
Output Loss	dB	-7.47	-7.47	-8.85	-8.85	-5.24	-5.24
S/C TLM Ant Directivity	dB	5.00	5.00		5.00	-0.70	-0.70
S/C EIRP (dBW)	dBW	9.29	9.29		7.91	5.82	5.82
Required S/C EIRP (dBW)	dBW	8.80	8.80		7.40	5.30	5.30
Margin (dBW)	dBW	0.49	0.49		0.51	0.52	0.52
Free Space loss	dB	-214.19	-214.19	-214.19	-214.19	-214.19	-214.19
Gaseous Att	dB	-0.93	-0.75	-0.93	-0.75	-0.93	-0.75
Cloud Att	dB	-0.72		-0.72		-0.72	
Rain Fade	dB	-3.40		-3.40		-3.40	
Total Atmospheric loss	dB	-5.05	-0.75	-5.05	-0.75	-5.05	-0.75
Min Rx Isotropic Power (RIP)	dBW	-210.44	-206.14	-211.84	-207.54	-213.94	-209.64
Polarization Loss	dB	-0.22	-0.22	-0.22	-0.22	-0.10	-0.10
Ground Station G/T	dB/K	38.00	38.00	38.00	38.00	38.00	38.00
Receiver Temperature	K	225	225	225	225	225	225
Background Temperature	K	193	45	193	45	193	45
G/T Degradation	dB	-1.90	0.00	-1.90	0.00	-1.90	0.00
Boltzmann's Constant	dBW/kHz	-228.60	-228.60	-228.60	-228.60	-228.60	-228.60
C/No Received	dB-Hz	54.04	60.24	52.64	58.84	50.66	56.86
Data demodulation at BER=1E-6							
PCM Data Rate	kbps	1	1	1	1	1	1
Required C/No (single mode)	dB-Hz	**44.91**	**44.91**	**44.91**	**44.91**	**44.91**	**44.91**
Required C/No (SIMO mode)	**dB-Hz**	**50.60**	**50.60**	**50.60**	**50.60**	**50.60**	**50.60**
Margin* (single mode)	dB	**9.13**	**15.33**		**13.93**	**5.75**	**11.95**
Margin* (SIMO mode)	**dB**	**3.44**	**9.64**		**8.24**	**0.06**	**6.26**

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Section C3 Representative Interference Analyses

Table C-3.1. Assessment of Intrasystem Interference from the Communications Payload into a Telemetry Channel

	Units	TLM Horn	Forward Pipe
Min S/C EIRP	dBW	31.5	8.8
Max Downlink EIRP	dBW	68.1	68.1
Comm BW	MHz dBHz	400 86.0	400 86.0
Spectral Roll-off	dB	-12.0	-12.0
Interference EIRP density	dBW/Hz	-29.9	-29.9
C/Io	dBW/Hz	61.4	38.7

APPENDIX D

Representative Satellite Receive/Transmit Filter Characteristics

Figure D-1. Representative Receive Filtering for a 62.5 MHz Sub-Band of the 29.5-30.0 GHz Band

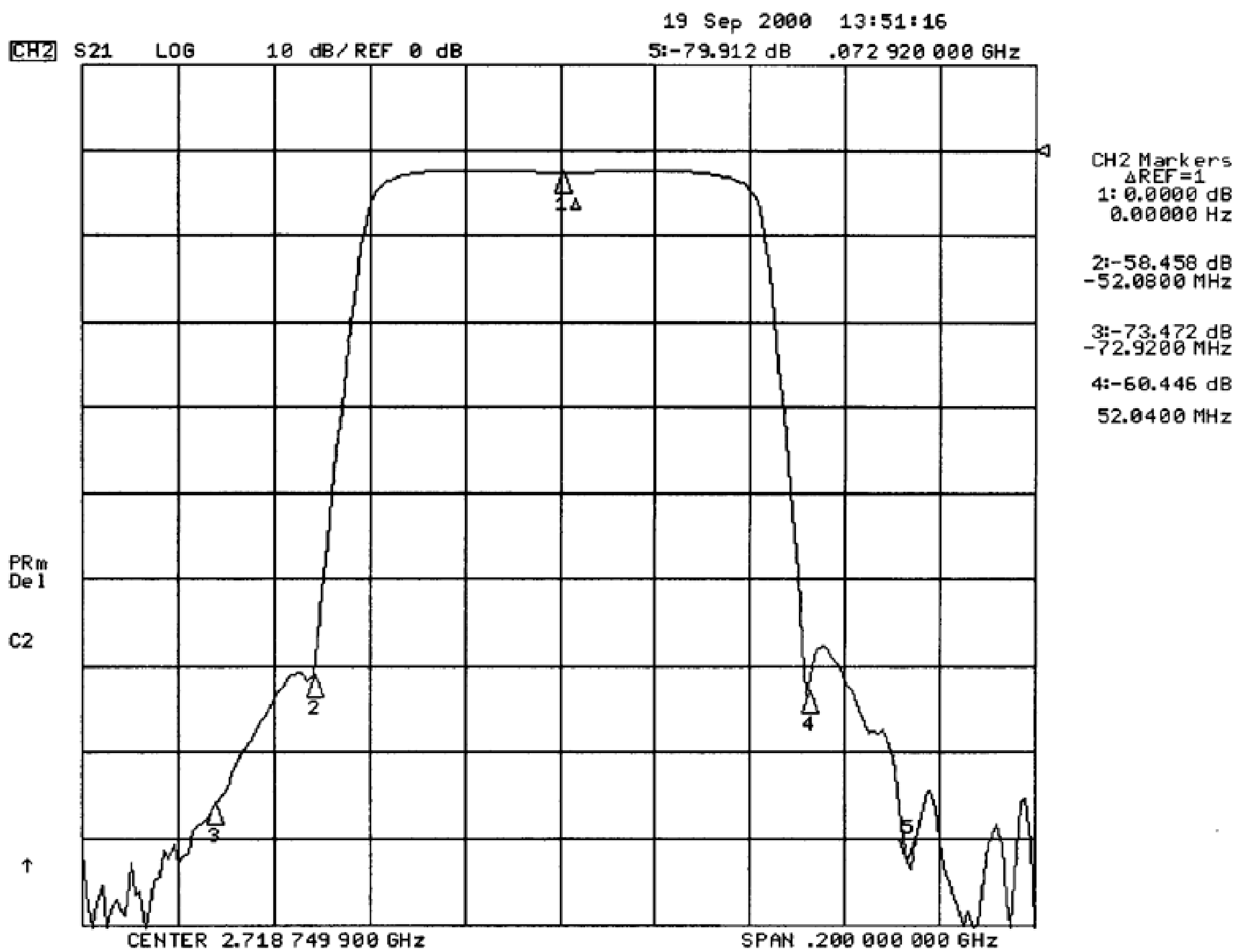

Figure D-2. Representative Receive Filtering for the 28.35-28.6 GHz Band

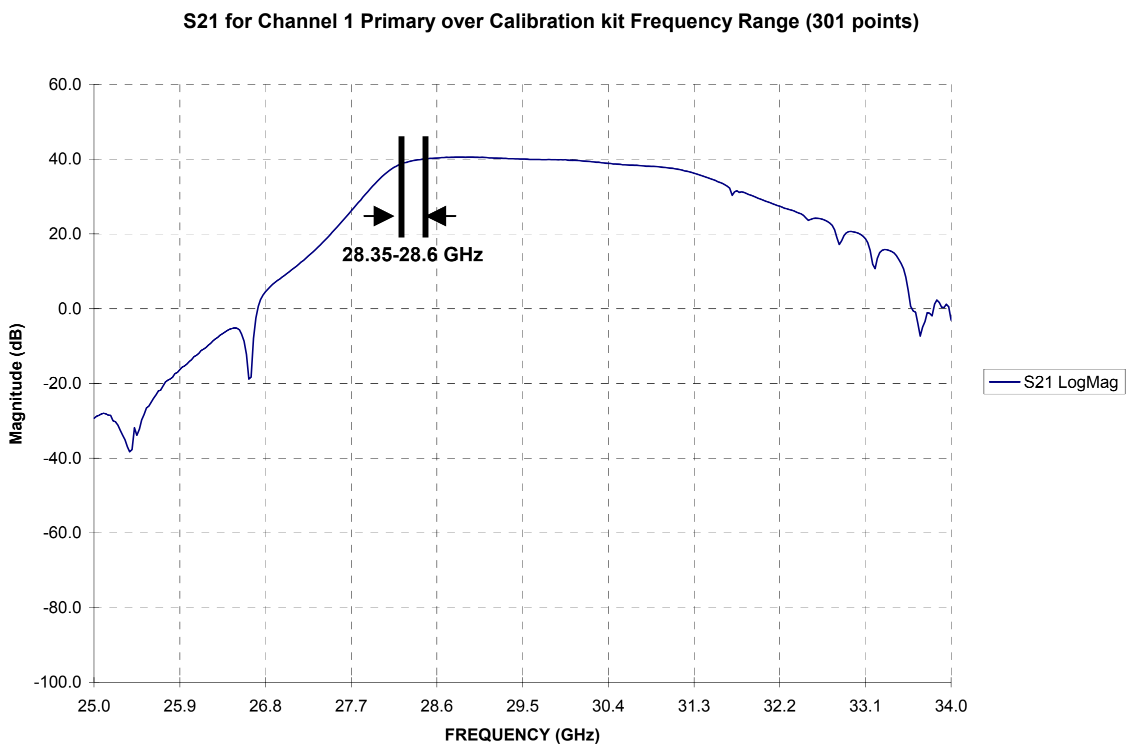

Figure D-3. Representative Receive Filtering for the 29.25-30.0 GHz Band

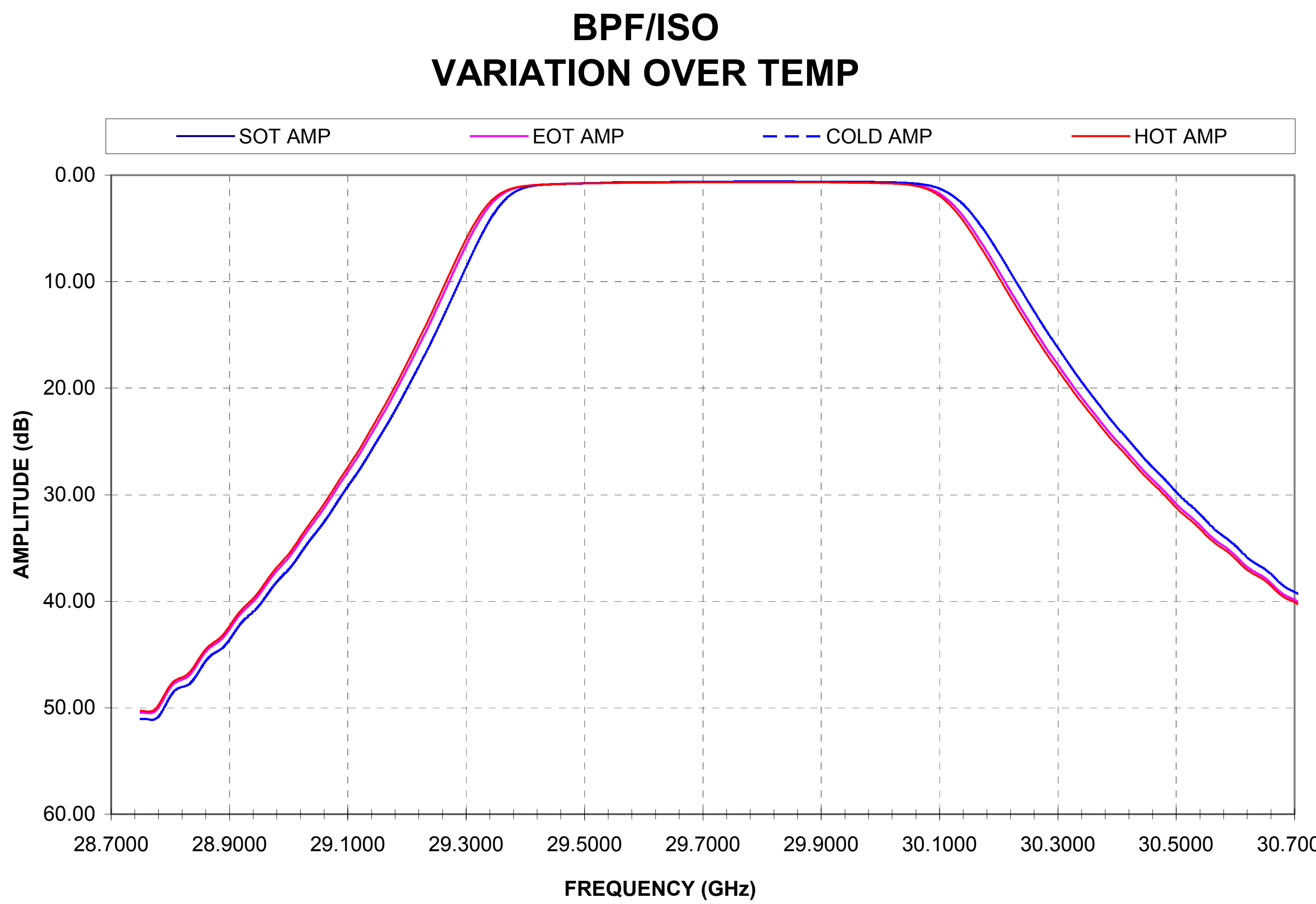

Figure D-4. Representative Transmit Filtering for 19.7-20.2 GHz Non-Processing Mode and for 18.3-18.55 GHz and 18.55-18.8 GHz Bands