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

Application of	)	
DIRECTV ENTERPRISES, LLC	)	Call Sign: S2712
For Minor Modification of Authorization to Launch and Operate DIRECTV RB-2	)	File No. SAT-MOD-_____

APPLICATION FOR MINOR MODIFICATION OF AUTHORITY TO LAUNCH AND OPERATE DIRECTV RB-2

On July 27, 2009, the Commission authorized DIRECTV Enterprises, LLC ("DIRECTV") to launch and operate DIRECTV RB-2, a 17/24 GHz BSS satellite, at the nominal 103° W.L. orbital location.[1] Since that time, DIRECTV has contracted for a multi-band, multi-mission satellite known as DIRECTV 15, which will carry a full 17/24 GHz BSS payload that will operate under the DIRECTV RB-2 authorization.[2] The construction of DIRECTV 15 is now nearing completion and, accordingly, in this Application DIRECTV requests that its 17/24 GHz BSS authorization be modified in the manner set forth herein so that it will conform to the parameters of the satellite currently under construction.

While the number of changes proposed herein is fairly numerous, upon review it becomes clear that the changes are relatively minor refinements to what was previously

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1 *See DIRECTV Enterprises, LLC*, 24 FCC Rcd. 9393 (Int'l Bur. 2009).

2 DIRECTV recently filed an application for authority to operate the Ka-band payload on the DIRECTV 15 satellite, as well as information related to the 12/17 GHz BSS payload that will not be licensed or operated at this time. *See* Application Narrative, IBFS File No. SAT-LOA-20140604-00055 (filed Jun. 4, 2014) ("D15 Application"). As discussed in greater detail below, certain aspects of that application are relevant to this application as well, and have been incorporated by reference.

requested and authorized. Indeed, the changes proposed herein do not involve a request for additional orbital or spectrum resources, and thus should be deemed minor in nature.[3]

In accordance with Section 25.117(d)(1) of the Commission's rules, DIRECTV identifies in this Application only those items of information that should be changed from its original application. For ease of reference, DIRECTV is also submitting a Schedule S, which includes all of the revised technical information relevant to the 17/24 GHz BSS payload. DIRECTV hereby certifies that the remaining information in its original application and the Schedule S that accompanied it has not changed.

I. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

DIRECTV is the nation's leading provider of satellite direct-to-home video services, with over 20 million subscribers. It began operations with a single satellite operating in the Ku-band Broadcasting Satellite Service frequencies at a single orbital location. In order to keep up with consumers' demand for more video content and the increasing bandwidth required to deliver such content (especially in high definition), DIRECTV currently operates a fleet of satellites operating in the both Ku- and Ka-bands. In order to meet future demand, including the impending introduction of high-bandwidth programming in Ultra HD format, DIRECTV is now adding a third frequency band to its operations – the 17/24 GHz BSS band. The DIRECTV RB-2 payload is an important part of that expansion effort.

Since grant of its original license, DIRECTV has worked with its satellite manufacturer to optimize operational parameters in the 17/24 GHz BSS band, consistent with all applicable Commission rules. As a result, certain aspects of those operations as originally envisioned have changed slightly. Granting this Application will serve the

[3] *See* 47 C.F.R. § 25.117(d)(2)(iii) (defining major modification requests that must be placed in a processing queue pursuant to Section 25.158).

public interest by conforming DIRECTV's authorization to the parameters of the satellite currently under construction, and thus help enable DIRECTV to become the first satellite operator to provide commercial service using the 17/24 GHz BSS band.

For the foregoing reasons, DIRECTV submits that the Commission should grant this Application as expeditiously as possible.

II. INFORMATION REQUIRED UNDER SEC. 25.114 OF THE COMMISSION'S RULES, AS REVISED[4]

In this section, we present those aspects of DIRECTV's original application for authority to operate DIRECTV RB-2 that it proposes to modify. For ease of comparison, the subsection headings in the discussion below correspond to the headings of the relevant subsections from the original application.

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

As discussed above, DIRECTV RB-2 is now a 17/24 GHz BSS payload on a multi-band, multi-mission satellite known as DIRECTV 15. While the coverage area for the payload has not changed, the manner in which that area will be covered by the downlink beams has been modified. In addition, one of the two previously identified uplink locations has also changed. As discussed below, the TT&C for the overall satellite is now no longer in the 17/24 GHz BSS band, but rather in one of the bands used by

[4] In a recent Public Notice, the International Bureau set forth an interim waiver policy with regard to a number of satellite application information requirements. (*See* Public Notice, "International Bureau Adopts Policy of Granting Interim Waiver of Certain Requirements for Space Station Applications," 29 FCC Rcd. 664 (Int'l Bur. 2014)). The information contained in this application and the accompanying Schedule S is consistent with the policy set forth in that Public Notice. Accordingly, DIRECTV requests grant of a waiver of the information requirements covered by the policy set forth therein. Notably, DIRECTV seeks a waiver of Section 25.114(c)(4)(vi), which requires applicants to specify the gain of each transponder channel including any adjustable gain step capabilities. As required by Footnote 6 of the Public Notice, DIRECTV has entered a value of "1" in columns q and r of Table S7. Further in accordance with the instructions provided in Footnote 6, and in reliance thereon, DIRECTV states that such entries in these data fields are outside the scope of DIRECTV's certification concerning the accuracy of information provided in this application.

another payload on the satellite. Finally, there are a number of other, smaller changes to the payload's operations, which are discussed below.

5.1 Frequency/Channelization and Polarization Plan

Details of the DIRECTV RB-2 frequency/channelization and polarization plan for the communications channels have not changed. As mentioned above, however, the TT&C frequencies are no longer in the 17/24 GHz BSS band, but are now in the Ka-band.[5] All uplink communications channels will be fed to DIRECTV RB-2 from two distinct sites, these being the DIRECTV uplink facilities in Moxee, WA ("NWUF") and New Hampton, NH ("NEUF"), whereas previously these were NWUF and the DIRECTV facility in Tucson, AZ ("SWUF"). The national channels will be delivered to the 48 contiguous states ("CONUS") plus Alaska through a single beam, and to Hawaii and Puerto Rico through dedicated spot beams, whereas previously this combined coverage was provided with a single beam. All these beams will carry identical national HD programming material.

5.2.1 Uplink Transmissions

The maximum G/T of the DIRECTV RB-2 satellite is specified in the accompanying Schedule S, which is hereby incorporated by reference as if fully set forth herein. Note that the previous G/T value of 17.5 dB/K has changed to 21.5 dB/K. The minimum saturation flux density for each uplink beam is specified in the Schedule S and the maximum saturation flux density is -80.7 dBW/m^2 for beam S4 and -78.8 dBW/m^2 for beam S5.

[5] The parameters for TT&C operations are discussed fully in the D15 Application. *See* D15 Application at 11-15 and App. B.

5.2.2 Downlink Transmissions

The maximum EIRP and EIRP density of the downlink beams will be as follows:

Beam	Max EIRP (dBW/36 MHz)	Max EIRP density (dBW/MHz)
CONUS+AK	58.9	43.3
Hawaii	57.5	41.9
Puerto Rico	60.6	45.0

These maximum levels are also included in the accompany Schedule S. Note that the previous maximum EIRP of the single CONUS+AK+HI+PR beam was 58 dBW/36 MHz, and the maximum EIRP density was 42.4 dBW/MHz.

5.3 TT&C Subsystem

As DIRECTV RB-2 is now a payload on the DIRECTV 15 satellite, details of the TT&C subsystem can be found in the application for DIRECTV 15.[6]

6. Orbital Locations

DIRECTV seeks authority to operate DIRECTV RB-2 at 102.75° W.L. where it will be essentially collocated with the SPACEWAY 1, DIRECTV 10 and DIRECTV 12 satellites.[7] This will enable DIRECTV to use a single dish to receive signals from all four satellites.

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[6] *See id.*

[7] Note that SPACEWAY 1 is currently authorized to operate at 102.925° W.L., DIRECTV 10 is currently authorized to operate at 102.815° W.L. and DIRECTV 12 is currently authorized to operate at 102.765° W.L. Before DIRECTV 15 is launched, DIRECTV will file requests to slightly modify the orbital locations of these other two satellites such that the final configuration of these satellites will be DIRECTV 15 at 102.75° W.L., DIRECTV 12 at 102.80° W.L., and DIRECTV 10 at 102.85° W.L., with the east-west station keeping of each satellite maintained to within ±0.025°. The location of SPACEWAY 1 will remain unchanged in this new configuration.

7.1 Uplink Beams

DIRECTV RB-2 will receive communications signals from the DIRECTV uplink facilities in Moxee, WA and New Hampton, NH. The receive antenna gain contour for the DIRECTV RB-2 receive beams are given in GXT format in the accompanying Schedule S.

7.2 Downlink Beams

DIRECTV RB-2 will employ a multiple beam transmit antenna system for 17/24 GHz BSS service to provide U.S. national coverage. One beam will cover CONUS+Alaska, and individual spot beams will cover Hawaii and Puerto Rico. All beams will be capable of transmitting across the frequency band 17.3-17.7 GHz using LHCP and RHCP. The antenna gain contours, in GXT format, are given in the accompanying Schedule S.

7.3 TT&C Beams

As discussed in Section 5.3, DIRECTV RB-2 is now a payload on the DIRECTV 15 satellite. The details of the TT&C beams for this satellite can be found in the application for DIRECTV 15.

8.2 Link Performance

Representative communications link budgets for DIRECTV RB-2 are shown in Appendix A as Tables A-1 to A-5, *i.e.*, one for a city in each of the CONUS downlink power flux density ("PFD") regions defined by the Commission's rules, and one each for Hawaii and Puerto Rico. Because DIRECTV is applying for an orbital location that is offset 0.25° from an Appendix F slot, these budgets include an entry for adjacent satellite interference ("ASI") from neighboring 17/24 GHz BSS satellites nominally spaced 3.75º, 4.25º, 7.75º and 8.25º away.

9. Satellite Orbit Characteristics

DIRECTV RB-2 will be maintained in geosynchronous orbit at the 102.75º W.L. orbital location with a maximum N-S drift of ± 0.05°, and a maximum E-W drift of ± 0.025°. The antenna axis attitude will be maintained within a time-weighted 3σ value of ± 0.1° for all modes of operation.

10. Power Flux Density

The allowable PFD levels in the 17.3-17.7 GHz band are defined in Section 25.208(w) of the Commission's rules on a regional basis for all conditions, including clear sky, and for all methods of modulation as:

(1) In the region of the contiguous United States, located south of 38º North Latitude and east of 100º West Longitude: -115 dBW/m^2/MHz;

(2) In the region of the contiguous United States, located north of 38º North Latitude and east of 100º West Longitude: -118 dBW/m^2/MHz;

(3) In the region of the contiguous United States, located west of 100º West Longitude: -121 dBW/m^2/MHz; and

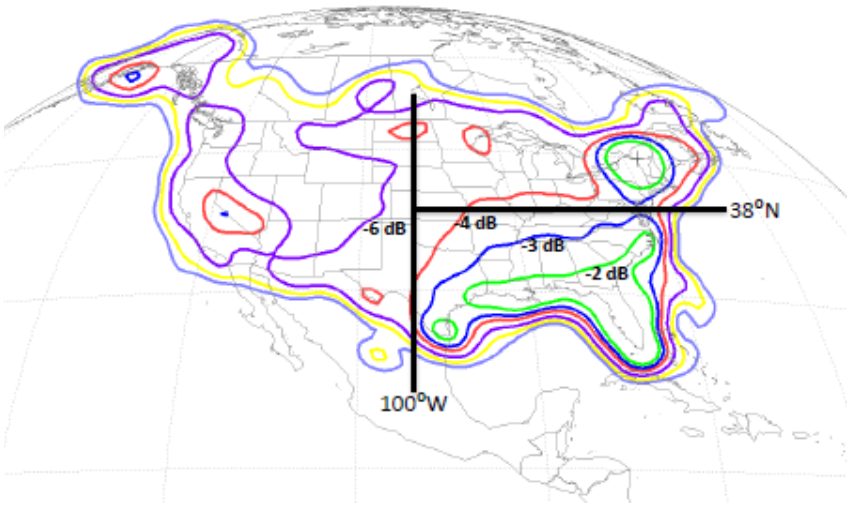
(4) For all regions outside of the contiguous United States including Alaska and Hawaii: -115 dBW/m^2/MHz.

As discussed in Section 5.2.2 above, the maximum downlink EIRP for DIRECTV RB-2 in the CONUS+AK beam will be 58.9 dBW/36 MHz channel. DIRECTV calculates the maximum power flux density on the Earth's surface from this emission as: Max EIRP/channel minus spreading loss in direction of max gain minus bandwidth correction factor, or 58.9 dBW/36MHz – 162.4 (dB-m^2) – 10log(36) = -119.1 dBW/m^2/MHz. The maximum downlink EIRP for regions outside of the contiguous United States is 60.6 dBW which, through the same calculation, results in a maximum power flux density of -117.4 dBW/MHz.

Because DIRECTV RB-2 will be placed at 102.75º W.L. rather than the Appendix F slot of 103° W.L., there will be 0.25º less spacing between DIRECTV RB-2 and the next closest on-grid location established in the *BSS R&O*. This slight offset results in 0.7 dB less discrimination from this adjacent location.[8] The maximum PFD calculated above, which is 4.1 dB less than the maximum allowed in Section 25.208(w)(1) for CONUS and 2.4 dB less than the maximum allowed for regions outside of CONUS, accounts for this slight reduction in discrimination from this next closest location as required under Section 25.140(b)(4)(iii). This means that the DIRECTV RB-2 system is necessarily compliant with the PFD levels established in Sections 25.208(c) and 25.208(w)(1) and (4).

As discussed in Section 7.2 above, the downlink antenna gain pattern for DIRECTV RB-2 is included in GXT format in the accompanying Schedule S, and is also represented below for the CONUS+AK beam. Inspection of this pattern shows that (1) the antenna peak gain is north of 38º North latitude and east of 100º W.L., but as discussed above the peak PFD density for this beam of -119.1 dBW/MHz complies with both Section 25.208(w)(1) and (w)(2); and (2) the antenna relative gain west of 100º W.L. is at least 4 dB below peak gain, which means that the peak PFD density in this region is below -123.1 dBW/MHz, making this beam compliant with Section 25.208(w)(3). As a result, the maximum PFD on the earth's surface complies with Section 25.208(w) in each of the applicable regions defined in the Commission's rules.

[8] This value is based on the reduction of topocentric angle and the assumption of a 45 cm receive antenna that meets the reference antenna pattern of Section 25.224.



11. Arrangement for Tracking, Telemetry, and Control

DIRECTV has contracted with Intelsat Satellite Operations to perform the TT&C operations for DIRECTV 15. The Intelsat control center is located in Long Beach, CA. The primary TT&C uplink will come from DIRECTV's Castle Rock Broadcast Center, in Castle Rock, CO. The backup TT&C uplink will come from DIRECTV's Northeast uplink facility in New Hampton, NH.

17. Interference Analysis

In order to achieve maximum compatibility between diverse networks, the Commission has established coordination thresholds for earth station off-axis EIRP density and spacecraft PFD in Sections 25.223 and 25.208, respectively. As such, DIRECTV has assumed for the purposes of this application regional maximum downlink PFD values from neighboring systems consistent with Section 25.208(w), maximum feeder link earth station off-axis transmit power density consistent with Section 25.223, and receive earth station compliance with Section 25.224 (*i.e.*, Recommendation ITU-R BO.1213).

The interference analyses that are included in this application were performed in conjunction with the end-to-end link performance analyses. Abbreviated link budgets are

presented in Tables A-1 through A-5 in Appendix A, *i.e.* one budget for each of the CONUS PFD regions defined in Section 25.208(w) and one budget for each of Hawaii and Puerto Rico. In each case, the analysis includes the effects of adjacent satellite interference from satellites nominally spaced 3.75º, 4.25º, 7.75º and 8.25º away in evaluating whether the system accommodates the various data rates at acceptable C/(N+I) thresholds. Additionally, adjacent satellite interference was calculated assuming 0.5° mis-pointing of the receive antenna and 0.05° station-keeping of the interfering satellites. Tables A-1 to A-5 of Appendix A demonstrate that the DIRECTV RB-2 design described in this application is compatible with the aforementioned transmission parameters and interference environment. Accordingly, the proposed 17/24 GHz BSS satellite would operate successfully in such an environment.

To properly account for interference from adjacent operating satellite systems, the uplink budgets include aggregate interference from earth terminals associated with satellites at 3.75º, 4.25º, 7.75º and 8.25º of orbit separation. On the uplink, the budgets include a level of interference that accounts for the maximum level of off-axis EIRP permissible under Section 25.223. On the downlink, the satellites at 3.75º, 4.25º, 7.75º and 8.25º of orbit separation are each assumed to produce an interference level equivalent to the maximum PFD value permissible under Section 25.208(w) at that geographical location. In all cases it is shown that the system, as proposed, will be able to operate successfully in this interference environment. DIRECTV recognizes that it must accept any increased interference from compliant systems operating at Appendix F slots that may result from operating DIRECTV RB-2 at a slight offset from the on-grid slot at 103° W.L.

18. Orbital Debris Mitigation

As discussed in this application, DIRECTV RB-2 is now a payload on the DIRECTV 15 satellite. The details of the orbital debris mitigation plan for the satellite can be found in the application for DIRECTV 15, and is hereby incorporated as if fully set forth herein.

Respectfully submitted,

DIRECTV ENTERPRISES, LLC

By: __/s/_____
Romulo Pontual
Executive Vice President

ENGINEERING CERTIFICATION

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

(i) I am the technically qualified person responsible for the engineering information contained in the foregoing Application,

(ii) I am familiar with Part 25 of the Commission's Rules, and

(iii) I have either prepared or reviewed the engineering information contained in the foregoing Application, and it is complete and accurate to the best of my knowledge and belief.

Signed:

/s/
Jack Wengryniuk

June 12, 2014
Date

APPENDIX A

DIRECTV RB-2 LINK BUDGET ANALYSIS

Reverse Band 102.75W	Miami	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	56.9	56.9
	Free space loss, dB	208.7	208.7
	Gaseous	0.4	0.4
	Cloud	0.6	0.6
	Scintillation	0.4	0.4
17.5 GHz	Downlink rain loss, dB	0.0	5.8
	Rain temp increase, dB	0.0	4.0
	Rain + Atmos Loss, dB	1.2	6.9
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**17.7**	**7.0**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	17.7	7.0
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	16.6	16.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**14.4**	**14.4**
	Total C/(N+I), dB	**12.4**	**6.2**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**7.7**	**1.5**

Table A-1. DIRECTV RB-2 Link Budget – Downlink to Miami

Reverse Band 102.75W	Chicago	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	54.9	54.9
Chicago	Free space loss, dB	208.8	208.8
	Gaseous	0.4	0.4
	Cloud	0.7	0.7
	Scintillation	0.5	0.5
17.5 GHz	Downlink rain loss, dB	0.0	2.9
	Rain temp increase, dB	0.0	3.3
	Rain + Atmos Loss, dB	1.3	4.0
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**15.6**	**8.5**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	15.6	8.5
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	17.6	17.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**15.0**	**15.0**
	Total C/(N+I), dB	**11.9**	**7.5**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**7.2**	**2.8**

Table A-2. DIRECTV RB-2 Link Budget – Downlink to Chicago

Reverse Band 102.75W	Los Angeles	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	52.9	52.9
Los Angeles	Free space loss, dB	208.8	208.8
	Gaseous	0.4	0.4
	Cloud	0.2	0.2
	Scintillation	0.3	0.3
17.5 GHz	Downlink rain loss, dB	0.0	1.6
	Rain temp increase, dB	0.0	2.1
	Rain + Atmos Loss, dB	0.8	2.2
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**14.1**	**9.5**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	14.1	9.5
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	18.6	18.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**15.5**	**15.5**
	Total C/(N+I), dB	**11.4**	**8.4**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**6.7**	**3.7**

Table A-3. DIRECTV RB-2 Link Budget – Downlink to Los Angeles

Reverse Band 102.75W	Honolulu	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	57.5	57.5
Honolulu	Free space loss, dB	209.3	209.3
	Gaseous	0.6	0.6
	Cloud	1.5	1.5
	Scintillation	0.9	0.9
17.5 GHz	Downlink rain loss, dB	0.0	7.3
	Rain temp increase, dB	0.0	4.7
	Rain + Atmos Loss, dB	2.3	9.4
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	23.2	23.2
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**21.9**	**9.1**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	21.9	9.1
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	22.6	22.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**17.0**	**17.0**
	Total C/(N+I), dB	**15.1**	**8.3**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**10.4**	**3.6**

Table A-4. DIRECTV RB-2 Link Budget – Downlink to Honolulu

Reverse Band 102.75W	San Juan PR	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	60.6	60.6
San Juan PR	Free space loss, dB	208.9	208.9
	Gaseous	0.2	0.2
	Cloud	0.2	0.2
	Scintillation	0.3	0.3
17.5 GHz	Downlink rain loss, dB	0.0	4.9
	Rain temp increase, dB	0.0	3.5
	Rain + Atmos Loss, dB	0.6	5.3
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**21.9**	**12.6**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	21.9	12.6
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	20.3	20.3
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**16.3**	**16.3**
	Total C/(N+I), dB	**14.6**	**10.8**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**9.9**	**6.1**

Table A-5. DIRECTV RB-2 Link Budget – Downlink to San Juan