1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		Suite 12				Video/Phone				
5	Link		Sub to Hub				Hub to Sub				
6	Modulation		QPSK or AM				FM				
7	Digital Data Rate		1.544 Mbps				N/A				
8	Channel Bandwidth		1 MHz				20 MHz				
9	Antenna Pattern Used		Proponent				Proponent				
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3				
11											
12	Feeder Link System		IRIDIUM				IRIDIUM				
13											
98	Required Path Loss	dB	-171.3	-162.4	-152.3	-138.1	-134.3	-125.4	-115.3	-101.1	
99	Margin at 1 km (clear sky)	dB	-49.4	-40.4	-30.4	-16.1	-12.4	-3.5	6.6	20.8	
100	Required Separation (clear sky, no radio horizon)	km	97.3	55.9	25.0	6.1	4.0	1.8	0.6	0.1	
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-45.7	-36.7	-26.7	-12.4	-8.7	0.2	10.3	24.5	
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	36.7	16.5	5.9	2.3	1.9	1.0	0.4	0.1	
103	Path Loss Allocation:										
104	Free Space	dB	153.1	146.2	137.2	129.2	127.3	121.7	113.8	100.7	
105	Atmosphere	dB	3.7	1.7	0.6	0.2	0.2	0.1	0.0	0.0	
106	Rain	dB	14.5	14.5	14.5	8.6	6.9	3.6	1.5	0.3	
107	*LMDS 6 degree Sidelobe*										
108	Required Path Loss	dB	-171.3	-162.4	-152.3	-138.1	-105.4	-96.5	-86.4	-72.2	
109	Margin at 1 km (clear sky)	dB	-49.4	-40.4	-30.4	-16.1	16.6	25.4	35.6	49.7	
110	Required Separation (clear sky, no radio horizon)	km	97.3	55.9	25.0	6.1	0.2	0.1	0.0	0.0	
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-45.7	-36.7	-26.7	-12.4	20.2	29.1	39.2	53.4	
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	36.7	16.5	5.9	2.3	0.1	0.1	0.0	0.0	
113	Path Loss Allocation:										
114	Free Space	dB	153.1	146.2	137.2	129.2	104.9	96.3	86.3	72.2	
115	Atmosphere	dB	3.7	1.7	0.6	0.2	0.0	0.0	0.0	0.0	
116	Rain	dB	14.5	14.5	14.5	8.6	0.5	0.2	0.1	0.0	
117	*LMDS 45 degree Sidelobe*										
118	Required Path Loss	dB	-171.3	-162.4	-152.3	-138.1	-88.3	-79.4	-69.3	-55.1	
119	Margin at 1 km (clear sky)	dB	-49.4	-40.4	-30.4	-16.1	33.6	42.5	52.6	66.8	
120	Required Separation (clear sky, no radio horizon)	km	97.3	55.9	25.0	6.1	0.0	0.0	0.0	0.0	
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-45.7	-36.7	-26.7	-12.4	37.3	46.2	56.3	70.5	
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	36.7	16.5	5.9	2.3	0.0	0.0	0.0	0.0	
123	Path Loss Allocation:										
124	Free Space	dB	153.1	146.2	137.2	129.2	88.3	79.3	69.3	55.1	
125	Atmosphere	dB	3.7	1.7	0.6	0.2	0.0	0.0	0.0	0.0	
126	Rain	dB	14.5	14.5	14.5	8.6	0.1	0.0	0.0	0.0	
127	*LMDS 180 degree Backlobe*										
128	Required Path Loss	dB	-171.3	-162.4	-152.3	-138.1	-32.3	-73.4	-63.3	-49.1	
129	Margin at 1 km (clear sky)	dB	-49.4	-40.4	-30.4	-16.1	39.6	48.5	58.6	72.8	
130	Required Separation (clear sky, no radio horizon)	km	97.3	55.9	25.0	6.1	0.0	0.0	0.0	0.0	
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-45.7	-36.7	-26.7	-12.4	43.3	52.2	62.3	76.5	
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	36.7	16.5	5.9	2.3	0.0	0.0	0.0	0.0	
133	Path Loss Allocation:										
134	Free Space	dB	153.1	146.2	137.2	129.2	82.3	73.4	63.3	49.1	
135	Atmosphere	dB	3.7	1.7	0.6	0.2	0.0	0.0	0.0	0.0	
136	Rain	dB	14.5	14.5	14.5	8.6	0.0	0.0	0.0	0.0	
137											
138											
139	LMDS Signal: rain Satellite Signal: rain										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		Suite 12					Video/Phone			
5	Link		Sub to Hub					Hub to Hub			
6	Modulation		QPSK or AM					FM			
7	Digital Data Rate		1.544 Mbps					N/A			
8	Channel Bandwidth		1 MHz					20 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System		IRIDIUM					IRIDIUM			
13											
140	ES angle from boresight		5	10	20	48		5	10	20	48
141	*LMDS Boresight*										
142	Required Path Loss	dB	-186.3	-177.4	-167.3	-153.1		-149.3	-140.4	-130.3	-116.1
143	Margin at 1 km (clear sky)	dB	-64.4	-55.4	-45.4	-31.1		-27.4	-18.5	-8.4	5.8
144	Required Separation (clear sky, no radio horizon)	km	189.5	131.6	77.2	26.8		19.1	7.8	2.6	0.5
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-60.7	-51.7	-41.7	-27.4		-23.7	-14.8	-4.7	9.5
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	99.9	57.8	26.1	8.4		4.3	2.7	1.4	0.4
147	Path Loss Allocation:										
148	Free Space	dB	161.8	157.1	150.1	137.9		134.4	130.3	124.9	114.4
149	Atmosphere	dB	10.0	5.8	2.6	0.6		0.4	0.3	0.1	0.0
150	Rain	dB	14.5	14.5	14.5	14.5		14.5	9.8	5.3	1.6
151	*LMDS 5 degree Sidelobe*										
152	Required Path Loss	dB	-186.3	-177.4	-167.3	-153.1		-120.4	-111.5	-101.4	-87.2
153	Margin at 1 km (clear sky)	dB	-64.4	-55.4	-45.4	-31.1		1.5	10.4	20.5	34.7
154	Required Separation (clear sky, no radio horizon)	km	189.5	131.6	77.2	26.8		0.8	0.3	0.1	0.0
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-60.7	-51.7	-41.7	-27.4		5.2	14.1	24.2	38.4
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	99.9	57.8	26.1	8.4		0.8	0.3	0.1	0.0
157	Path Loss Allocation:										
158	Free Space	dB	161.8	157.1	150.1	137.9		118.0	110.4	101.0	87.1
159	Atmosphere	dB	10.0	5.8	2.6	0.6		0.1	0.0	0.0	0.0
160	Rain	dB	14.5	14.5	14.5	14.5		2.4	1.0	0.3	0.1
161	*LMDS 45 degree Sidelobe*										
162	Required Path Loss	dB	-186.3	-177.4	-167.3	-153.1		-103.3	-94.4	-84.3	-70.1
163	Margin at 1 km (clear sky)	dB	-64.4	-55.4	-45.4	-31.1		18.6	27.5	37.6	51.8
164	Required Separation (clear sky, no radio horizon)	km	189.5	131.6	77.2	26.8		0.1	0.0	0.0	0.0
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-60.7	-51.7	-41.7	-27.4		22.3	31.2	41.3	55.5
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	99.9	57.8	26.1	8.4		0.1	0.0	0.0	0.0
167	Path Loss Allocation:										
168	Free Space	dB	161.8	157.1	150.1	137.9		102.8	94.2	84.2	70.1
169	Atmosphere	dB	10.0	5.8	2.6	0.6		0.0	0.0	0.0	0.0
170	Rain	dB	14.5	14.5	14.5	14.5		0.4	0.2	0.0	0.0
171	*LMDS 180 degree Backlobe*										
172	Required Path Loss	dB	-186.3	-177.4	-167.3	-153.1		-97.3	-88.4	-78.3	-64.1
173	Margin at 1 km (clear sky)	dB	-64.4	-55.4	-45.4	-31.1		24.6	33.5	43.6	57.8
174	Required Separation (clear sky, no radio horizon)	km	189.5	131.6	77.2	26.8		0.1	0.0	0.0	0.0
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-60.7	-51.7	-41.7	-27.4		28.3	37.2	47.3	61.5
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	99.9	57.8	26.1	8.4		0.1	0.0	0.0	0.0
177	Path Loss Allocation:										
178	Free Space	dB	161.8	157.1	150.1	137.9		97.1	88.3	78.3	64.1
179	Atmosphere	dB	10.0	5.8	2.6	0.6		0.0	0.0	0.0	0.0
180	Rain	dB	14.5	14.5	14.5	14.5		0.2	0.1	0.0	0.0

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				Video/Phone			
5	Link		Hub to Sub				Sub to Hub			
6	Modulation		AM				16 QAM			
7	Digital Data Rate		N/A				45 Mbps			
8	Channel Bandwidth		4.2 MHz				22.5 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System		IRIDIUM							
13										
14	Required Separation (clear sky, incl. 100 km radio horizon)									
15	ES angle from boresight		5	10	20	48	5	10	20	48
16	LMDS receiver pointing angle									
17	Boresight	km	69.6	35.7	14.3	3.2	8.5	3.2	1.0	0.2
18	5 Degree Sidelobe	km	5.1	1.9	0.6	0.1	6.1	2.3	0.7	0.1
19	45 Degree Sidelobe	km	0.8	0.3	0.1	0.0	0.2	0.1	0.0	0.0
20	180 Degree Backlobe	km	0.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0
21										
22	Calculations									
23										
24	LMDS Signal Link Carrier Level at Cell Edge		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
25	Transmitted Power	dBW/channel	-15.8		-15.8		-20		-20	
26	Transmitter Antenna Gain	dBi	29.7		29.7		38		38	
27	EIRP (clear sky)	dBWi/channel	13.9		13.9		18		18	
28	Power Control (rain)	dB	0		5.8		0		5.8	
29	Distance to Cell Edge	km	1.61		1.61		1.61		1.61	
30	Rain Attenuation (cell edge)	dB	0		-5.8		0		-5.8	
31	Free Space Path Loss (cell edge)	dB	-125.9		-125.9		-125.9		-125.9	
32	Receiver Antenna Gain	dBi	38		38		29.9		29.9	
33	Carrier Level at Cell Edge	dBW/channel	-74.0		-74.0		-78.0		-78.0	
34	Notes:									
35	Rain attenuation from WG1/52 (rev. 3)									
36	Power control is the minimum necessary to overcome rain fade without exceeding maximum		Video/Phone max power control: 11 dB				Video/Phone max power control: 10 dB			
37										
38										
39	Interference Density into LMDS		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
40	k (Boltzmann's Constant)	dBW/K/Hz	-228.6		-228.6		-228.6		-228.6	
41	Receiver Noise Figure	dB	7.5		7.5		7.5		7.5	
42	Receiver Noise Temperature	K	1631		1631		1631		1631	
43	Channel Bandwidth	MHz	6		6		22.5		22.5	
44	Receiver Noise Floor	dBW/channel	-128.7		-128.7		-123.0		-123.0	
45	Minimum Required C/(N + I)	dB per channel	52		52		27		27	
46	Cell Edge C/N	dB	54.6		54.6		44.9		44.9	
47	Cell Edge C/N	linear	291608		291608		30958		30958	
48	Required C/(N + I)	linear	158489		158489		501		501	
49	Maximum Acceptable Interference	dBW/channel	-129.5		-129.5		-105.1		-105.1	
50	Maximum Acceptable Interference Density	dBW/Hz	-197.2		-197.2		-178.6		-178.6	
51	Notes:									
52										
53										
54	Interference Density Generated									
55	IRIDIUM Feeder Links into LMDS Receivers									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		Video/Phone					Video/Phone			
5	Link		Hub to Sub					Sub to Hub			
6	Modulation		AM					16 QAM			
7	Digital Data Rate		N/A					45 Mbps			
8	Channel Bandwidth		4.2 MHz					22.5 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System		IRIDIUM								
13											
56											
57	ES angle from boresight	degrees	5	10	20	48		5	10	20	48
58	Earth Station Output Power (no rain)	dBWi/channel	-12.8	-12.8	-12.8	-12.8		-12.8	-12.8	-12.8	-12.8
59	Slant Path Length	km	2741.1	2325.7	1732.4	1006.9		2741.1	2325.7	1732.4	1006.9
60	Power Control (slant path)	dB	1.5	0.0	-2.5	-7.2		1.5	0.0	-2.5	-7.2
61	Antenna Gain	dBi	14.5	7.0	-0.5	-10.0		14.5	7.0	-0.5	-10.0
62	Single Channel BW	MHz	4.375	4.375	4.375	4.375		4.375	4.375	4.375	4.375
63	Number of Interfering Channels	dB	0	0	0	0		3	3	3	3
64	LMDS Receiver Bandwidth	MHz	20	20	20	20		22.5	22.5	22.5	22.5
65	Interference Density Subtotal (clear sky)	dBW/Hz	-69.8	-78.8	-88.9	-103.1		-67.3	-76.3	-86.4	-100.6
66	Rain Rate	mm/hr	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
67	Length of rain cell	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
68	Path Length through rain	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
69	Rain Attenuation	dB	15	15	15	15		15	15	15	15
70	Power Control (rain)	dB	15.0	15.0	15.0	15.0		15.0	15.0	15.0	15.0
71	Interference Density Subtotal (rain on signal path)	dBW/Hz	-54.8	-63.8	-73.9	-88.1		-52.3	-61.3	-71.4	-85.6
72	Notes:										
73	Antenna Gain is the maximum elevation pattern gain in the direction of the LMDS receiver w										
74	the earth station is pointing in the direction of the LMDS receiver										
75	Antenna Gain is 32-25 *log(theta)										
76	Power Control (slant path) is the difference in EIRP required to offset the path loss along th										
77	Eb/No at the satellite receiver										
78	The default slant path (0 dB power control) is for a 10 degree elevation angle										
79	Total Power Control (rain plus slant path) cannot exceed 24.8 dB										
80	Interference Density Subtotal calculated based on AWGN assumption										
81	may be a low estimate of interference										
82	Lin Model used for rain attenuation on interference path										
83	Assume rain fade of 15 dB on satellite signal path										
84	Maximum rain cell 4 km long										
85											
86											
87	LMDS Receiver Antenna Gain										
88	Boresight	dBi	38					29.5			
89	5 Degree Sidelobe	dBi	9.1					20.5			
90	45 Degree Sidelobe	dBi	-8					-4.1			
91	180 Degree Backlobe	dB	-14					-12.8			
92	Note:										
93	Negative margin indicates C/(N + I) objective not met at 1 km separation										
94	All path loss values indicate positive loss (negative gain) regardless of sign										
95	LMDS Signal: clear sky, Satellite Signal: clear sky										
96	ES angle from boresight		5	10	20	48		5	10	20	48
97	*LMDS Boresight*										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				Video/Phone			
5	Link		Hub to Sub				Sub to Hub			
6	Modulation		AM				16 QAM			
7	Digital Data Rate		N/A				45 Mbps			
8	Channel Bandwidth		4.2 MHz				22.5 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System		IRIDIUM							
13										
98	Required Path Loss	dB	-165.4	-156.5	-146.4	-132.1	-141.2	-132.2	-122.2	-107.9
99	Margin at 1 km (clear sky)	dB	-43.5	-34.5	-24.5	-10.2	-19.3	-10.3	-0.2	14.0
100	Required Separation (clear sky, no radio horizon)	km	68.6	35.7	14.3	3.2	8.8	3.2	1.0	0.2
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-39.8	-30.8	-20.8	-6.5	-15.6	-6.6	3.5	17.7
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	22.0	9.1	3.6	1.6	2.8	1.6	0.7	0.2
103	Path Loss Allocation:									
104	Free Space	dB	148.7	141.0	132.9	126.0	130.7	128.1	119.3	107.2
105	Atmosphere	dB	2.2	0.9	0.4	0.2	0.3	0.2	0.1	0.0
106	Rain	dB	14.5	14.5	13.1	6.0	10.2	6.0	2.8	0.7
107	*LMDS 6 degree Sidelobe*									
108	Required Path Loss	dB	-136.5	-127.6	-117.5	-103.2	-128.2	-129.2	-119.2	-104.9
109	Margin at 1 km (clear sky)	dB	-14.6	-5.6	4.4	18.7	-16.3	-7.3	2.8	17.0
110	Required Separation (clear sky, no radio horizon)	km	5.1	1.9	0.6	0.1	6.1	2.3	0.7	0.1
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-10.9	-1.9	8.1	22.4	-12.6	-3.6	6.5	20.7
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.1	1.2	0.5	0.1	2.4	1.3	0.6	0.1
113	Path Loss Allocation:									
114	Free Space	dB	128.4	123.1	115.6	102.8	129.3	124.2	117.0	104.4
115	Atmosphere	dB	0.2	0.1	0.0	0.0	0.2	0.1	0.1	0.0
116	Rain	dB	7.9	4.3	1.8	0.4	8.7	4.9	2.1	0.5
117	*LMDS 46 degree Sidelobe*									
118	Required Path Loss	dB	-119.4	-110.5	-100.4	-86.1	-107.2	-98.2	-88.2	-73.9
119	Margin at 1 km (clear sky)	dB	2.5	11.5	21.6	35.8	14.7	23.7	33.8	48.0
120	Required Separation (clear sky, no radio horizon)	km	0.8	0.3	0.1	0.0	0.2	0.1	0.0	0.0
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	6.2	15.2	25.2	39.5	18.4	27.4	37.5	51.7
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.6	0.2	0.1	0.0	0.2	0.1	0.0	0.0
123	Path Loss Allocation:									
124	Free Space	dB	117.2	109.5	100.1	86.1	106.5	98.0	88.1	73.0
125	Atmosphere	dB	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
126	Rain	dB	2.2	0.9	0.3	0.1	0.6	0.2	0.1	0.0
127	*LMDS 180 degree Backlobe*									
128	Required Path Loss	dB	-113.4	-104.5	-94.4	-80.1	-98.5	-89.5	-79.5	-65.2
129	Margin at 1 km (clear sky)	dB	8.5	17.5	27.5	41.8	23.4	32.4	42.5	56.7
130	Required Separation (clear sky, no radio horizon)	km	0.4	0.1	0.0	0.0	0.1	0.0	0.0	0.0
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	12.2	21.2	31.2	45.5	27.1	36.1	46.2	60.4
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0
133	Path Loss Allocation:									
134	Free Space	dB	112.2	104.0	94.2	80.1	98.2	89.5	79.4	65.2
135	Atmosphere	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
136	Rain	dB	1.2	0.5	0.2	0.0	0.2	0.1	0.0	0.0
137										
138										
139	LMDS Signal: rain Satellite Signal: rain									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				Video/Phone			
5	Link		Hub to Sub				Sub to Hub			
6	Modulation		AM				16 QAM			
7	Digital Data Rate		N/A				45 Mbps			
8	Channel Bandwidth		4.2 MHz				22.5 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System		IRIDIUM							
13										
140	ES angle from boresight		5	10	20	48	5	10	20	48
141	*LMDS Boresight*									
142	Required Path Loss	dB	-180.4	-171.5	-161.4	-147.1	-156.2	-147.2	-137.2	-122.9
143	Margin at 1 km (clear sky)	dB	-58.5	-49.5	-39.5	-25.2	-34.3	-25.3	-15.2	-1.0
144	Required Separation (clear sky, no radio horizon)	km	150.4	98.1	52.1	15.6	35.0	18.6	5.6	1.1
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-54.8	-45.8	-35.8	-21.5	-30.6	-21.6	-11.5	2.7
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	70.7	37.1	15.0	3.7	8.9	3.7	2.2	0.8
147	Path Loss Allocation:									
148	Free Space	dB	158.8	153.2	145.3	133.2	140.8	133.3	126.8	119.9
149	Atmosphere	dB	7.1	3.7	1.5	0.4	0.9	0.4	0.2	0.1
150	Rain	dB	14.5	14.5	14.5	13.5	14.6	13.6	8.2	3.0
151	*LMDS 6 degree Sidelobe*									
152	Required Path Loss	dB	-151.5	-142.6	-132.5	-118.2	-153.2	-144.2	-134.2	-119.9
153	Margin at 1 km (clear sky)	dB	-29.6	-20.6	-10.6	3.7	-31.3	-22.3	-12.2	2.0
154	Required Separation (clear sky, no radio horizon)	km	23.3	9.7	3.3	0.7	27.1	11.6	4.0	0.8
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-25.9	-16.9	-6.9	7.4	-27.6	-18.6	-8.5	5.7
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	5.4	3.0	1.7	0.5	6.5	3.3	1.9	0.6
157	Path Loss Allocation:									
158	Free Space	dB	136.4	131.3	126.2	118.2	138.0	132.1	127.2	117.6
159	Atmosphere	dB	0.5	0.3	0.2	0.1	0.6	0.3	0.2	0.1
160	Rain	dB	14.5	10.9	6.1	2.0	14.6	11.9	6.8	2.3
161	*LMDS 45 degree Sidelobe*									
162	Required Path Loss	dB	-134.4	-125.5	-115.4	-101.1	-122.2	-113.2	-103.2	-88.9
163	Margin at 1 km (clear sky)	dB	-12.5	-3.5	6.5	20.8	-0.3	8.7	18.8	33.0
164	Required Separation (clear sky, no radio horizon)	km	4.1	1.5	0.5	0.1	1.0	0.4	0.1	0.0
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-8.8	0.2	10.2	24.5	3.1	12.4	22.5	36.7
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	1.9	1.0	0.4	0.1	0.8	0.3	0.1	0.0
167	Path Loss Allocation:									
168	Free Space	dB	127.3	121.7	113.6	100.8	119.3	112.0	102.7	88.9
169	Atmosphere	dB	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0
170	Rain	dB	6.9	3.6	1.5	0.3	2.8	1.2	0.4	0.1
171	*LMDS 180 degree Backlobe*									
172	Required Path Loss	dB	-128.4	-119.5	-109.4	-95.1	-113.5	-104.5	-94.5	-80.2
173	Margin at 1 km (clear sky)	dB	-6.5	2.5	12.5	26.8	8.4	17.4	27.5	41.7
174	Required Separation (clear sky, no radio horizon)	km	2.1	0.8	0.2	0.0	0.4	0.1	0.0	0.0
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-2.8	6.2	16.2	30.5	12.1	21.1	31.2	45.4
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	1.2	0.6	0.2	0.0	0.3	0.1	0.0	0.0
177	Path Loss Allocation:									
178	Free Space	dB	123.7	117.2	108.5	95.0	112.2	104.1	94.3	80.2
179	Atmosphere	dB	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
180	Rain	dB	4.6	2.2	0.6	0.2	1.2	0.5	0.2	0.0

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				TI Dig Hub #1			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				QPSK			
7	Digital Data Rate		1.544 Mbps				52 Mbps			
8	Channel Bandwidth		1.544 MHz				52 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
14	Required Separation (clear sky, incl. 100 km radio horizon)									
15	ES angle from boresight		5	10	20	48	5	10	20	48
16	LMDS receiver pointing angle									
17	Boresight	km	3.2	1.2	0.4	0.1	81.3	24.9	9.3	2.0
18	5 Degree Sidelobe	km	2.3	0.8	0.3	0.1	6.5	2.4	0.8	0.2
19	45 Degree Sidelobe	km	0.1	0.0	0.0	0.0	2.8	1.0	0.3	0.1
20	180 Degree Backlobe	km	0.0	0.0	0.0	0.0	2.8	1.0	0.3	0.1
21										
22	Calculations									
23										
24	LMDS Signal Link Carrier Level at Cell Edge		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
25	Transmitted Power	dBW/channel	-28		-28		-12		-12	
26	Transmitter Antenna Gain	dBi	38		38		12		12	
27	EIRP (clear sky)	dBWi/channel	10		10		0		0	
28	Power Control (rain)	dB	0		5.8		0		12	
29	Distance to Cell Edge	km	1.61		1.61		5		5	
30	Rain Attenuation (cell edge)	dB	0		-5.8		0		-15	
31	Free Space Path Loss (cell edge)	dB	-125.9		-125.9		-135.8		-135.8	
32	Receiver Antenna Gain	dBi	29.9		29.9		34		34	
33	Carrier Level at Cell Edge	dBW/channel	-86.0		-86.0		-101.8		-104.8	
34	Notes:									
35	Rain attenuation from WG1/52 (rev. 3)						Antenna gains include pointing loss			
36	Power control is the minimum necessary to overcome rain fade without exceeding maximum		Video/Phone max power control: 8 dB				TI max power control: 12 dB			
37										
38										
39	Interference Density Into LMDS		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
40	k (Boltzmann's Constant)	dBW/K/Hz	-228.6		-228.6		-228.6		-228.6	
41	Receiver Noise Figure	dB	7.5		7.5		8		8	
42	Receiver Noise Temperature	K	1631		1631		1830		1830	
43	Channel Bandwidth	MHz	1.544		1.544		52		52	
44	Receiver Noise Floor	dBW/channel	-134.6		-134.6		-111.8		-118.8	
45	Minimum Required C/(N+I)	dB per channel	13		13		13		13	
46	Cell Edge C/N	dB	48.5		48.5		17.0		14.0	
47	Cell Edge C/N	linear	71499		71499		50		25	
48	Required C/(N+I)	linear	20		20		20		20	
49	Maximum Acceptable Interference	dBW/channel	-99.0		-99.0		-117.0		-124.6	
50	Maximum Acceptable Interference Density	dBW/Hz	-160.9		-160.9		-181.1		-201.7	
51	Notes:									
52										
53										
54	Interference Density Generated									
55	IRIDIUM Feeder Links Into LMDS Receivers									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				TI Dig Hub #1			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				QPSK			
7	Digital Data Rate		1.544 Mbps				52 Mbps			
8	Channel Bandwidth		1.544 MHz				52 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
56										
57	ES angle from boresight	degrees	5	10	20	48	5	10	20	48
58	Earth Station Output Power (no rain)	dBWi/channel	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8
59	Slant Path Length	km	2741.1	2325.7	1732.4	1006.9	2741.1	2325.7	1732.4	1006.9
60	Power Control (slant path)	dB	1.5	0.0	-2.5	-7.2	1.5	0.0	-2.5	-7.2
61	Antenna Gain	dBi	14.5	7.0	-0.5	-10.0	14.5	7.0	-0.5	-10.0
62	Single Channel BW	MHz	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375
63	Number of Interfering Channels	dB	0	0	0	0	6	6	6	6
64	LMDS Receiver Bandwidth	MHz	1.544	1.544	1.544	1.544	52	52	52	52
65	Interference Density Subtotal (clear sky)	dBW/Hz	-58.7	-67.7	-77.7	-92.0	-68.0	-76.9	-87.0	-101.2
66	Rain Rate	mm/hr	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
67	Length of rain cell	km	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
68	Path Length through rain	km	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
69	Rain Attenuation	dB	15	15	15	15	15	15	15	15
70	Power Control (rain)	dB	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
71	Interference Density Subtotal (rain on signal path)	dBW/Hz	-43.7	-52.7	-62.7	-77.0	-53.0	-61.9	-72.0	-86.2
72	Notes:									
73	Antenna Gain is the maximum elevation pattern gain in the direction of the LMDS receiver w									
74	the earth station is pointing in the direction of the LMDS receiver									
75	Antenna Gain is 32-25 *log(theta)									
76	Power Control (slant path) is the difference in EIRP required to offset the path loss along th									
77	Eb/No at the satellite receiver									
78	The default slant path (0 dB power control) is for a 10 degree elevation angle									
79	Total Power Control (rain plus slant path) cannot exceed 24.8 dB									
80	Interference Density Subtotal calculated based on AWGN assumption									
81	may be a low estimate of interference									
82	Lin Model used for rain attenuation on interference path									
83	Assume rain fade of 15 dB on satellite signal path									
84	Maximum rain cell 4 km long									
85										
86										
87	LMDS Receiver Antenna Gain									
88	Boresight	dBi	29.9				35			
89	5 Degree Sidelobe	dBi	26.9				12.6			
90	45 Degree Sidelobe	dBi	-4.1				5			
91	180 Degree Backlobe	dBi	-12.8				5			
92	Note:									
93	Negative margin indicates C/(N + I) objective not met at 1 km separation									
94	All path loss values indicate positive loss (negative gain) regardless of sign									
95	LMDS Signal: clear sky, Satellite Signal: clear sky									
96	ES angle from boresight		5	10	20	48	5	10	20	48
97	*LMDS Boresight*									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		Video/Phone					TI Dig Hub #1			
5	Link		Sub to Hub					Hub to Sub			
6	Modulation		QPSK					QPSK			
7	Digital Data Rate		1.544 Mbps					52 Mbps			
8	Channel Bandwidth		1.544 MHz					52 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System										
13											
98	Required Path Loss	dB	-132.1	-123.2	-113.1	-98.9		-161.2	-152.2	-142.1	-127.9
99	Margin at 1 km (clear sky)	dB	-10.2	-1.3	8.8	23.0		-39.2	-30.3	-20.2	-6.0
100	Required Separation (clear sky, no radio horizon)	km	3.2	1.2	0.4	0.1		51.3	24.9	9.3	2.0
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-6.5	2.4	12.5	26.7		-35.5	-26.6	-16.5	-2.3
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	1.6	0.8	0.3	0.1		14.7	5.6	2.9	1.2
103	Path Loss Allocation:										
104	Free Space	dB	126.0	120.1	111.9	98.6		145.2	137.1	131.1	123.4
105	Atmosphere	dB	0.2	0.1	0.0	0.0		1.5	0.6	0.3	0.1
106	Rain	dB	6.0	3.0	1.2	0.3		14.5	14.5	10.7	4.4
107	*LMDS 5 degree Sidelobe*										
108	Required Path Loss	dB	-129.1	-120.2	-110.1	-95.9		-135.8	-129.6	-119.7	-105.5
109	Margin at 1 km (clear sky)	dB	-7.2	1.7	11.8	26.0		-16.8	-7.9	2.2	16.4
110	Required Separation (clear sky, no radio horizon)	km	2.3	0.8	0.3	0.1		6.6	2.4	0.8	0.2
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-3.5	5.4	15.5	29.7		-13.1	-4.2	5.8	20.1
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	1.3	0.6	0.2	0.0		2.4	1.4	0.6	0.1
113	Path Loss Allocation:										
114	Free Space	dB	124.2	117.8	109.2	95.7		129.6	124.6	117.4	105.0
115	Atmosphere	dB	0.1	0.1	0.0	0.0		0.2	0.1	0.1	0.0
116	Rain	dB	4.8	2.3	0.9	0.2		6.0	5.1	2.2	0.5
117	*LMDS 45 degree Sidelobe*										
118	Required Path Loss	dB	-98.1	-89.2	-79.1	-64.9		-131.2	-122.2	-112.1	-97.9
119	Margin at 1 km (clear sky)	dB	23.8	32.7	42.8	57.0		-9.2	-0.3	9.8	24.0
120	Required Separation (clear sky, no radio horizon)	km	0.1	0.0	0.0	0.0		2.8	1.0	0.3	0.1
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	27.5	36.4	46.5	60.7		-5.5	3.4	13.5	27.7
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.1	0.0	0.0	0.0		1.5	0.8	0.3	0.1
123	Path Loss Allocation:										
124	Free Space	dB	97.9	89.1	79.1	64.9		125.4	119.3	111.0	97.7
125	Atmosphere	dB	0.0	0.0	0.0	0.0		0.2	0.1	0.0	0.0
126	Rain	dB	0.2	0.1	0.0	0.0		5.6	2.8	1.1	0.2
127	*LMDS 180 degree Backlobe*										
128	Required Path Loss	dB	-89.4	-80.5	-70.4	-56.2		-131.2	-122.2	-112.1	-97.9
129	Margin at 1 km (clear sky)	dB	32.5	41.4	51.5	65.7		-9.2	-0.3	9.8	24.0
130	Required Separation (clear sky, no radio horizon)	km	0.0	0.0	0.0	0.0		2.8	1.0	0.3	0.1
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	35.2	45.1	55.2	69.4		-5.5	3.4	13.5	27.7
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.0	0.0	0.0	0.0		1.5	0.8	0.3	0.1
133	Path Loss Allocation:										
134	Free Space	dB	89.3	80.4	70.4	56.2		125.4	119.3	111.0	97.7
135	Atmosphere	dB	0.0	0.0	0.0	0.0		0.2	0.1	0.0	0.0
136	Rain	dB	0.1	0.0	0.0	0.0		5.6	2.8	1.1	0.2
137											
138											
139	LMDS Signal: rain Satellite Signal: rain										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		Video/Phone				TI Dig Hub #1			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				QPSK			
7	Digital Data Rate		1.544 Mbps				52 Mbps			
8	Channel Bandwidth		1.544 MHz				52 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
140	ES angle from boresight		5	10	20	48	5	10	20	48
141	*LMDS Boresight*									
142	Required Path Loss	dB	-147.1	-138.2	-128.1	-113.9	-113.7	-174.8	-164.7	-150.5
143	Margin at 1 km (clear sky)	dB	-25.2	-16.3	-6.2	8.0	11.8	-52.9	-42.8	-28.6
144	Required Separation (clear sky, no radio horizon)	km	15.4	6.1	2.0	0.4	172.1	116.5	65.6	21.2
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-21.5	-12.6	-2.5	11.7	-58.1	-49.2	-39.1	-24.9
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.7	2.4	1.2	0.3	86.5	48.1	20.6	4.8
147	Path Loss Allocation:									
148	Free Space	dB	133.2	129.3	123.5	112.6	160.6	155.4	148.1	135.5
149	Atmosphere	dB	0.4	0.2	0.1	0.0	8.7	4.8	2.1	0.5
150	Rain	dB	13.5	8.7	4.5	1.3	14.5	14.5	14.5	4.5
151	*LMDS 5 degree Sidelobe*									
152	Required Path Loss	dB	-144.1	-135.2	-125.1	-110.9	-161.3	-152.4	-142.3	-128.1
153	Margin at 1 km (clear sky)	dB	-22.2	-13.3	-3.2	11.0	-39.4	-30.5	-20.4	-6.2
154	Required Separation (clear sky, no radio horizon)	km	11.4	4.4	1.4	0.3	82.0	25.3	9.5	2.0
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-18.5	-9.6	0.8	14.7	-35.7	-26.8	-16.7	-2.5
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.2	2.0	1.0	0.3	15.0	5.9	3.0	1.2
157	Path Loss Allocation:									
158	Free Space	dB	132.0	127.7	121.5	109.9	146.3	137.3	131.2	120.5
159	Atmosphere	dB	0.3	0.2	0.1	0.0	1.5	0.6	0.3	0.1
160	Rain	dB	11.8	7.3	3.5	0.9	14.5	14.5	10.8	4.5
161	*LMDS 45 degree Sidelobe*									
162	Required Path Loss	dB	-113.1	-104.2	-94.1	-79.9	-153.7	-144.8	-134.7	-120.5
163	Margin at 1 km (clear sky)	dB	8.8	17.7	27.8	42.0	-31.8	-22.9	-12.8	1.4
164	Required Separation (clear sky, no radio horizon)	km	0.4	0.1	0.0	0.0	28.4	12.2	4.2	0.8
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	12.5	21.4	31.5	45.7	-28.1	-19.2	-9.1	5.1
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.3	0.1	0.0	0.0	8.8	3.3	1.9	0.6
167	Path Loss Allocation:									
168	Free Space	dB	111.9	103.7	93.9	79.8	138.5	132.3	127.5	118.0
169	Atmosphere	dB	0.0	0.0	0.0	0.0	0.7	0.3	0.2	0.1
170	Rain	dB	1.2	0.5	0.1	0.0	14.5	12.2	7.0	2.4
171	*LMDS 180 degree Backlobe*									
172	Required Path Loss	dB	-104.4	-95.5	-85.4	-71.2	-153.7	-144.8	-134.7	-120.5
173	Margin at 1 km (clear sky)	dB	17.5	26.4	36.5	50.7	-31.8	-22.9	-12.8	1.4
174	Required Separation (clear sky, no radio horizon)	km	0.1	0.0	0.0	0.0	28.4	12.2	4.2	0.8
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	21.2	30.1	40.2	54.4	-28.1	-19.2	-9.1	5.1
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	0.1	0.0	0.0	0.0	8.8	3.3	1.9	0.6
177	Path Loss Allocation:									
178	Free Space	dB	103.9	95.3	85.3	71.2	138.5	132.3	127.5	118.0
179	Atmosphere	dB	0.0	0.0	0.0	0.0	0.7	0.3	0.2	0.1
180	Rain	dB	0.5	0.2	0.1	0.0	14.5	12.2	7.0	2.4

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		T1 Dig Sub #1					T1 Dig #2			
5	Link		Sub to Hub					Hub to Sub			
6	Modulation		QPSK					QPSK			
7	Digital Data Rate		52 Mbps					5.2 Mbps			
8	Channel Bandwidth		52 MHz					5.2 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System										
13											
14	Required Separation (clear sky, incl. 100 km radio horizon)										
15	ES angle from boresight		5	10	20	48		5	10	20	48
16	LMDS receiver pointing angle										
17	Boresight	km	8.4	3.2	1.0	0.2		67.5	35.0	14.0	3.1
18	5 Degree Sidelobe	km	8.4	3.2	1.0	0.2		9.9	3.8	1.2	0.2
19	45 Degree Sidelobe	km	8.4	3.2	1.0	0.2		4.4	1.6	0.5	0.1
20	180 Degree Backlobe	km	8.4	3.2	1.0	0.2		4.4	1.6	0.5	0.1
21											
22	Calculations										
23											
24	LMDS Signal Link Carrier Level at Cell Edge		Clear Sky		Rain Conditions			Clear Sky		Rain Conditions	
25	Transmitted Power	dBW/channel	-12		-12			-22		-22	
26	Transmitter Antenna Gain	dBi	34		34			12		12	
27	EIRP (clear sky)	dBW/channel	22		22			-10		-10	
28	Power Control (rain)	dB	0		12			0		12	
29	Distance to Cell Edge	km	5		5			5		5	
30	Rain Attenuation (cell edge)	dB	0		-15			0		-15	
31	Free Space Path Loss (cell edge)	dB	-135.8		-135.8			-135.8		-135.8	
32	Receiver Antenna Gain	dBi	12		12			34		34	
33	Carrier Level at Cell Edge	dBW/channel	-101.8		-104.8			-111.8		-114.8	
34	Notes:										
35	Rain attenuation from WG1/52 (rev. 3)		Antenna gains include pointing loss					Antenna gains include pointing loss			
36	Power control is the minimum necessary to overcome rain fade without exceeding maximum		T1 max power control: 12 dB					T1 max power control: 12 dB			
37											
38											
39	Interference Density into LMDS		Clear Sky		Rain Conditions			Clear Sky		Rain Conditions	
40	k (Boltzmann's Constant)	dBW/K/Hz	-228.6		-228.6			-228.6		-228.6	
41	Receiver Noise Figure	dB	8		8			8		8	
42	Receiver Noise Temperature	K	1830		1830			1830		1830	
43	Channel Bandwidth	MHz	52		52			5.2		5.2	
44	Receiver Noise Floor	dBW/channel	-118.8		-118.8			-128.8		-128.8	
45	Minimum Required C/(N + I)	dB per channel	13		13			13		13	
46	Cell Edge C/N	dB	17.0		14.0			17.0		14.0	
47	Cell Edge C/N	linear	50		25			50		25	
48	Required C/(N + I)	linear	20		20			20		20	
49	Maximum Acceptable Interference	dBW/channel	-117.0		-124.6			-127.0		-134.6	
50	Maximum Acceptable Interference Density	dBW/Hz	-194.1		-201.7			-194.1		-201.7	
51	Notes:										
52											
53											
54	Interference Density Generated										
55	IRIDIUM Feeder Links into LMDS Receivers										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig Sub #1					TI Dig #2			
5	Link		Sub to Hub					Hub to Sub			
6	Modulation		QPSK					QPSK			
7	Digital Data Rate		52 Mbps					5.2 Mbps			
8	Channel Bandwidth		52 MHz					5.2 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System										
13											
56											
57	ES angle from boresight	degrees	5	10	20	48		5	10	20	48
58	Earth Station Output Power (no rain)	dBW/channel	-12.8	-12.8	-12.8	-12.8		-12.8	-12.8	-12.8	-12.8
59	Slant Path Length	km	2741.1	2325.7	1732.4	1006.9		2741.1	2325.7	1732.4	1006.9
60	Power Control (slant path)	dB	1.5	0.0	-2.5	-7.2		1.5	0.0	-2.5	-7.2
61	Antenna Gain	dBi	14.5	7.0	-0.5	-10.0		14.5	7.0	-0.5	-10.0
62	Single Channel BW	MHz	4.375	4.375	4.375	4.375		4.375	4.375	4.375	4.375
63	Number of Interfering Channels	dB	6	6	6	6		0	0	0	0
64	LMDS Receiver Bandwidth	MHz	52	52	52	52		5.2	5.2	5.2	5.2
65	Interference Density Subtotal (clear sky)	dBW/Hz	-68.0	-76.9	-87.0	-101.2		-64.0	-72.9	-83.0	-97.2
66	Rain Rate	mm/hr	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
67	Length of rain cell	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
68	Path Length through rain	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
69	Rain Attenuation	dB	15	15	15	15		15	15	15	15
70	Power Control (rain)	dB	15.0	15.0	15.0	15.0		15.0	15.0	15.0	15.0
71	Interference Density Subtotal (rain on signal path)	dBW/Hz	-53.0	-61.9	-72.0	-86.2		-49.0	-57.9	-68.0	-82.2
72	Notes:										
73	Antenna Gain is the maximum elevation pattern gain in the direction of the LMDS receiver w										
74	the earth station is pointing in the direction of the LMDS receiver										
75	Antenna Gain is 32-25*log(theta)										
76	Power Control (slant path) is the difference in EIRP required to offset the path loss along th										
77	Eb/No at the satellite receiver										
78	The default slant path (0 dB power control) is for a 10 degree elevation angle										
79	Total Power Control (rain plus slant path) cannot exceed 24.8 dB										
80	Interference Density Subtotal calculated based on AWGN assumption										
81	may be a low estimate of interference										
82	Lin*Model used for rain attenuation on interference path										
83	Assume rain fade of 15 dB on satellite signal path										
84	Maximum rain cell 4 km long										
85											
86											
87	LMDS Receiver Antenna Gain										
88	Boresight	dBi	15					35			
89	5 Degree Sidelobe	dBi	15					12.6			
90	45 Degree Sidelobe	dBi	15					5			
91	180 Degree Backlobe	dBi	15					5			
92	Note:										
93	Negative margin indicates C/(N+I) objective not met at 1 km separation										
94	All path loss values indicate positive loss (negative gain) regardless of sign										
95	LMDS Signal: clear sky, Satellite Signal: clear sky										
96	ES angle from boresight		5	10	20	48		5	10	20	48
97	*LMDS Boresight*										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		TI Dig Sub #1				TI Dig #2			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				QPSK			
7	Digital Data Rate		52 Mbps				5.2 Mbps			
8	Channel Bandwidth		52 MHz				5.2 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
98	Required Path Loss	dB	-141.2	-132.2	-122.1	-107.9	-165.2	-156.2	-146.1	-131.9
99	Margin at 1 km (clear sky)	dB	-19.2	-10.3	-0.2	14.0	-43.2	-34.3	-24.2	-10.0
100	Required Separation (clear sky, no radio horizon)	km	8.4	3.2	1.0	0.2	67.8	35.0	14.0	3.1
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-15.5	-6.6	3.5	17.7	-13.5	-30.6	-20.5	-6.3
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.8	1.6	0.7	0.2	21.5	8.9	3.8	1.6
103	Path Loss Allocation:									
104	Free Space	dB	130.7	126.0	119.3	107.2	148.5	140.8	132.8	125.9
105	Atmosphere	dB	0.3	0.2	0.1	0.0	2.2	0.9	0.4	0.2
106	Rain	dB	10.2	6.0	2.8	0.7	14.5	14.5	12.9	5.9
107	*LMDS 5 degree Sidelobe*									
108	Required Path Loss	dB	-141.2	-132.2	-122.1	-107.9	-142.8	-133.8	-123.7	-109.5
109	Margin at 1 km (clear sky)	dB	-19.2	-10.3	-0.2	14.0	-20.8	-11.9	-1.8	12.4
110	Required Separation (clear sky, no radio horizon)	km	8.4	3.2	1.0	0.2	9.9	3.8	1.2	0.2
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-15.5	-6.6	3.5	17.7	-17.1	-8.2	1.9	16.1
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.8	1.6	0.7	0.2	3.0	1.8	0.9	0.2
113	Path Loss Allocation:									
114	Free Space	dB	130.7	126.0	119.3	107.2	131.4	127.0	120.5	108.7
115	Atmosphere	dB	0.3	0.2	0.1	0.0	0.3	0.2	0.1	0.0
116	Rain	dB	10.2	6.0	2.8	0.7	11.0	6.7	3.2	0.8
117	*LMDS 45 degree Sidelobe*									
118	Required Path Loss	dB	-141.2	-132.2	-122.1	-107.9	-135.2	-126.2	-116.1	-101.9
119	Margin at 1 km (clear sky)	dB	-19.2	-10.3	-0.2	14.0	-13.2	-4.3	5.8	20.0
120	Required Separation (clear sky, no radio horizon)	km	8.4	3.2	1.0	0.2	4.4	1.6	0.5	0.1
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-15.5	-6.6	3.5	17.7	-9.5	-0.6	9.5	23.7
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.8	1.6	0.7	0.2	2.0	1.0	0.4	0.1
123	Path Loss Allocation:									
124	Free Space	dB	130.7	126.0	119.3	107.2	127.7	122.2	114.5	101.5
125	Atmosphere	dB	0.3	0.2	0.1	0.0	0.2	0.1	0.0	0.0
126	Rain	dB	10.2	6.0	2.8	0.7	7.2	3.9	1.6	0.4
127	*LMDS 180 degree Backlobe*									
128	Required Path Loss	dB	-141.2	-132.2	-122.1	-107.9	-135.2	-126.2	-116.1	-101.9
129	Margin at 1 km (clear sky)	dB	-19.2	-10.3	-0.2	14.0	-13.2	-4.3	5.8	20.0
130	Required Separation (clear sky, no radio horizon)	km	8.4	3.2	1.0	0.2	4.4	1.6	0.5	0.1
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-15.5	-6.6	3.5	17.7	-9.5	-0.6	9.5	23.7
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.8	1.6	0.7	0.2	2.0	1.0	0.4	0.1
133	Path Loss Allocation:									
134	Free Space	dB	130.7	126.0	119.3	107.2	127.7	122.2	114.5	101.5
135	Atmosphere	dB	0.3	0.2	0.1	0.0	0.2	0.1	0.0	0.0
136	Rain	dB	10.2	6.0	2.8	0.7	7.2	3.9	1.6	0.4
137										
138										
139	LMDS Signal: rain Satellite Signal: rain									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig Sub #1				TI Dig #2				
5	Link		Sub to Hub				Hub to Sub				
6	Modulation		QPSK				QPSK				
7	Digital Data Rate		52 Mbps				5.2 Mbps				
8	Channel Bandwidth		52 MHz				5.2 MHz				
9	Antenna Pattern Used		*Proponent*				*Proponent*				
10	Date/Revision of System Parameters	WG 1/52	9/18/94 Rev 3				9/18/94 Rev 3				
11											
12	Feeder Link System										
13											
140	ES angle from boresight		5	10	20	48	5	10	20	48	
141	*LMDS Boresight*										
142	Required Path Loss	dB	-163.7	-154.8	-144.7	-130.5	-167.7	-178.8	-168.7	-154.5	
143	Margin at 1 km (clear sky)	dB	-41.8	-32.9	-22.8	-8.6	-65.8	-56.9	-46.8	-32.6	
144	Required Separation (clear sky, no radio horizon)	km	61.5	31.1	12.1	2.6	199.3	140.3	84.0	30.3	
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-38.1	-29.2	-19.1	-4.9	-62.1	-53.2	-43.1	-28.9	
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	18.9	7.7	3.3	1.4	107.6	63.7	29.5	7.4	
147	Path Loss Allocation:										
148	Free Space	dB	147.3	139.5	132.2	125.0	162.4	157.9	151.2	139.2	
149	Atmosphere	dB	1.9	0.8	0.3	0.1	10.8	6.4	3.0	0.7	
150	Rain	dB	14.5	14.5	12.1	5.3	14.5	14.5	14.5	14.5	
151	*LMDS 5 degree Sidelobe*										
152	Required Path Loss	dB	-163.7	-154.8	-144.7	-130.5	-165.3	-156.4	-146.3	-132.1	
153	Margin at 1 km (clear sky)	dB	-41.8	-32.9	-22.8	-8.6	-43.4	-34.5	-24.4	-10.2	
154	Required Separation (clear sky, no radio horizon)	km	61.5	31.1	12.1	2.6	66.3	35.6	14.2	3.1	
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-38.1	-29.2	-19.1	-4.9	-39.7	-30.8	-20.7	-6.5	
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	18.9	7.7	3.3	1.4	21.9	9.1	3.6	1.6	
157	Path Loss Allocation:										
158	Free Space	dB	147.3	139.5	132.2	125.0	148.6	141.0	132.9	126.0	
159	Atmosphere	dB	1.9	0.8	0.3	0.1	2.2	0.9	0.4	0.2	
160	Rain	dB	14.5	14.5	12.1	5.3	14.5	14.5	13.0	5.9	
161	*LMDS 45 degree Sidelobe*										
162	Required Path Loss	dB	-163.7	-154.8	-144.7	-130.5	-167.7	-148.8	-138.7	-124.5	
163	Margin at 1 km (clear sky)	dB	-41.8	-32.9	-22.8	-8.6	-35.8	-26.9	-16.8	-2.6	
164	Required Separation (clear sky, no radio horizon)	km	61.5	31.1	12.1	2.6	39.6	18.1	6.5	1.3	
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-38.1	-29.2	-19.1	-4.9	-32.1	-23.2	-13.1	1.1	
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	18.9	7.7	3.3	1.4	10.4	4.0	2.4	0.9	
167	Path Loss Allocation:										
168	Free Space	dB	147.3	139.5	132.2	125.0	142.2	133.9	129.5	121.0	
169	Atmosphere	dB	1.9	0.8	0.3	0.1	1.0	0.4	0.2	0.1	
170	Rain	dB	14.5	14.5	12.1	5.3	14.5	14.5	8.9	3.4	
171	*LMDS 180 degree Backlobe*										
172	Required Path Loss	dB	-163.7	-154.8	-144.7	-130.5	-157.7	-148.8	-138.7	-124.5	
173	Margin at 1 km (clear sky)	dB	-41.8	-32.9	-22.8	-8.6	-25.8	-26.9	-16.8	-2.6	
174	Required Separation (clear sky, no radio horizon)	km	61.5	31.1	12.1	2.6	39.6	18.1	6.5	1.3	
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-38.1	-29.2	-19.1	-4.9	-32.1	-23.2	-13.1	1.1	
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	18.9	7.7	3.3	1.4	10.4	4.0	2.4	0.9	
177	Path Loss Allocation:										
178	Free Space	dB	147.3	139.5	132.2	125.0	142.2	133.9	129.5	121.0	
179	Atmosphere	dB	1.9	0.8	0.3	0.1	1.0	0.4	0.2	0.1	
180	Rain	dB	14.5	14.5	12.1	5.3	14.5	14.5	8.9	3.4	

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig #2				TI #3				
5	Link		Sub to Hub				Hub to Sub				
6	Modulation		QPSK				FM				
7	Digital Data Rate		5 Mbps				N/A				
8	Channel Bandwidth		5.2 MHz				17 MHz				
9	Antenna Pattern Used		Proponent				Proponent				
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3				
11											
12	Feeder Link System										
13											
14	Required Separation (clear sky, incl. 100 km radio horizon)										
15	ES angle from boresight		5	10	20	48	5	10	20	48	
16	LMDS receiver pointing angle										
17	Boresight	km	12.7	5.0	1.6	0.3	48.1	22.9	8.5	1.8	
18	5 Degree Sidelobe	km	12.7	5.0	1.6	0.3	5.9	2.2	0.7	0.1	
19	45 Degree Sidelobe	km	12.7	5.0	1.6	0.3	2.6	0.9	0.3	0.1	
20	180 Degree Backlobe	km	12.7	5.0	1.6	0.3	2.6	0.9	0.3	0.1	
21											
22	Calculations										
23											
24	LMDS Signal Link Carrier Level at Cell Edge		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions		
25	Transmitted Power	dBW/channel	-22		-22		-12		-12		
26	Transmitter Antenna Gain	dBi	34		34		12		12		
27	EIRP (clear sky)	dBW/channel	12		12		0		0		
28	Power Control (rain)	dB	0		12		0		12		
29	Distance to Cell Edge	km	5		5		5		5		
30	Rain Attenuation (cell edge)	dB	0		-15		0		-15		
31	Free Space Path Loss (cell edge)	dB	-135.8		-135.8		-135.8		-135.8		
32	Receiver Antenna Gain	dBi	12		12		34		34		
33	Carrier Level at Cell Edge	dBW/channel	-111.8		-114.8		-101.8		-104.8		
34	Notes:										
35	Rain attenuation from WG1/52 (rev. 3)		Antenna gains include pointing loss				Antenna gains include pointing loss				
36	Power control is the minimum necessary to overcome rain fade without exceeding maximum		TI max power control: 12 dB				TI max power control: 12 dB				
37											
38											
39	Interference Density Into LMDS		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions		
40	k (Boltzmann's Constant)	dBW/K/Hz	-228.6		-228.6		-228.6		-228.6		
41	Receiver Noise Figure	dB	8		8		8		8		
42	Receiver Noise Temperature	K	1830		1830		1330		1830		
43	Channel Bandwidth	MHz	5.2		5.2		17		17		
44	Receiver Noise Floor	dBW/channel	-128.8		-128.8		-123.7		-123.7		
45	Minimum Required C/(N + I)	dB per channel	13		13		18		18		
46	Cell Edge C/N	dB	17.0		14.0		21.9		18.9		
47	Cell Edge C/N	linear	50		25		154		77		
48	Required C/(N + I)	linear	20		20		63		63		
49	Maximum Acceptable Interference	dBW/channel	-127.0		-134.8		-122.1		-130.1		
50	Maximum Acceptable Interference Density	dBW/Hz	-194.1		-201.7		-194.4		-202.5		
51	Notes:										
52											
53											
54	Interference Density Generated										
55	IRIDIUM Feeder Links Into LMDS Receivers										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig #2				TI #3				
5	Link		Sub to Hub				Hub to Sub				
6	Modulation		QPSK				FM				
7	Digital Data Rate		5 Mbps				N/A				
8	Channel Bandwidth		5.2 MHz				17 MHz				
9	Antenna Pattern Used		Proponent				Proponent				
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3				
11											
12	Feeder Link System										
13											
56											
57	ES angle from boresight	degrees	5	10	20	48	5	10	20	48	
58	Earth Station Output Power (no rain)	dBW/channel	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	-12.8	
59	Slant Path Length	km	2741.1	2325.7	1732.4	1006.9	2741.1	2325.7	1732.4	1006.9	
60	Power Control (slant path)	dB	1.5	0.0	-2.5	-7.2	1.5	0.0	-2.5	-7.2	
61	Antenna Gain	dBi	14.5	7.0	-0.5	-10.0	14.5	7.0	-0.5	-10.0	
62	Single Channel BW	MHz	4.375	4.375	4.375	4.375	4.375	4.375	4.375	4.375	
63	Number of Interfering Channels	dB	0	0	0	0	0	0	0	0	
64	LMDS Receiver Bandwidth	MHz	5.2	5.2	5.2	5.2	17	17	17	17	
65	Interference Density Subtotal (clear sky)	dBW/Hz	-64.0	-72.9	-83.0	-97.2	-69.1	-78.1	-88.2	-102.4	
66	Rain Rate	mm/hr	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
67	Length of rain cell	km	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
68	Path Length through rain	km	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
69	Rain Attenuation	dB	15	15	15	15	15	15	15	15	
70	Power Control (rain)	dB	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	
71	Interference Density Subtotal (rain on signal path)	dBW/Hz	-49.0	-57.9	-68.0	-82.2	-54.1	-63.1	-73.2	-87.4	
72	Notes:										
73	Antenna Gain is the maximum elevation pattern gain in the direction of the LMDS receiver w										
74	the earth station is pointing in the direction of the LMDS receiver										
75	Antenna Gain is 32-25*log(theta)										
76	Power Control (slant path) is the difference in EIRP required to offset the path loss along th										
77	Eb/No at the satellite receiver										
78	The default slant path (0 dB power control) is for a 10 degree elevation angle										
79	Total Power Control (rain plus slant path) cannot exceed 24.8 dB										
80	Interference Density Subtotal calculated based on AWGN assumption										
81	may be a low estimate of interference										
82	Lin Model used for rain attenuation on interference path										
83	Assume rain fade of 15 dB on satellite signal path										
84	Maximum rain cell 4 km long										
85											
86											
87	LMDS Receiver Antenna Gain										
88	Boresight	dBi	15				35				
89	5 Degree Sidelobe	dBi	15				12.6				
90	45 Degree Sidelobe	dBi	15				5				
91	180 Degree Backlobe	dBi	15				5				
92	Note:										
93	Negative margin indicates C/(N + I) objective not met at 1 km separation										
94	All path loss values indicate positive loss (negative gain) regardless of sign										
95	LMDS Signal: clear sky, Satellite Signal: clear sky										
96	ES angle from boresight		5	10	20	48	5	10	20	48	
97	*LMDS Boresight*										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		TI Dig #2				TI #3			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				FM			
7	Digital Data Rate		5 Mbps				N/A			
8	Channel Bandwidth		5.2 MHz				17 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
98	Required Path Loss	dB	-145.2	-136.2	-126.1	-111.9	-160.3	-151.3	-141.2	-127.0
99	Margin at 1 km (clear sky)	dB	-23.2	-14.3	-4.2	10.0	-38.3	-29.4	-19.3	-5.1
100	Required Separation (clear sky, no radio horizon)	km	12.7	5.0	1.6	0.3	48.1	22.9	8.5	1.8
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-19.5	-10.6	-0.5	13.7	-34.6	-25.7	-15.6	-1.4
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.4	2.1	1.0	0.3	13.4	5.3	2.8	1.1
103	Path Loss Allocation:									
104	Free Space	dB	132.4	128.3	122.2	110.8	144.4	136.2	130.7	122.8
105	Atmosphere	dB	0.3	0.2	0.1	0.0	1.3	0.5	0.3	0.1
106	Rain	dB	12.4	7.7	3.8	1.0	14.5	14.5	10.2	4.1
107	*LMDS 5 degree Sidelobe*									
108	Required Path Loss	dB	-145.2	-136.2	-126.1	-111.9	-137.9	-128.9	-118.8	-104.6
109	Margin at 1 km (clear sky)	dB	-23.2	-14.3	-4.2	10.0	-15.9	-7.0	3.1	17.3
110	Required Separation (clear sky, no radio horizon)	km	12.7	5.0	1.6	0.3	5.8	2.2	0.7	0.1
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-19.5	-10.6	-0.5	13.7	-12.2	-3.3	6.6	21.0
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.4	2.1	1.0	0.3	2.3	1.3	0.6	0.1
113	Path Loss Allocation:									
114	Free Space	dB	132.4	128.3	122.2	110.8	129.1	124.0	116.7	104.1
115	Atmosphere	dB	0.3	0.2	0.1	0.0	0.2	0.1	0.1	0.0
116	Rain	dB	12.4	7.7	3.8	1.0	8.5	4.8	2.1	0.5
117	*LMDS 45 degree Sidelobe*									
118	Required Path Loss	dB	-145.2	-136.2	-126.1	-111.9	-130.3	-121.3	-111.2	-97.0
119	Margin at 1 km (clear sky)	dB	-23.2	-14.3	-4.2	10.0	-8.3	0.6	10.7	24.9
120	Required Separation (clear sky, no radio horizon)	km	12.7	5.0	1.6	0.3	2.6	0.9	0.3	0.1
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-19.5	-10.6	-0.5	13.7	-4.6	4.3	14.4	28.6
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.4	2.1	1.0	0.3	1.4	0.7	0.3	0.1
123	Path Loss Allocation:									
124	Free Space	dB	132.4	128.3	122.2	110.8	124.9	118.7	110.2	96.8
125	Atmosphere	dB	0.3	0.2	0.1	0.0	0.1	0.1	0.0	0.0
126	Rain	dB	12.4	7.7	3.8	1.0	5.2	2.6	1.0	0.2
127	*LMDS 180 degree Backlobe*									
128	Required Path Loss	dB	-145.2	-136.2	-126.1	-111.9	-130.3	-121.3	-111.2	-97.0
129	Margin at 1 km (clear sky)	dB	-23.2	-14.3	-4.2	10.0	-8.3	0.6	10.7	24.9
130	Required Separation (clear sky, no radio horizon)	km	12.7	5.0	1.6	0.3	2.6	0.9	0.3	0.1
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-19.5	-10.6	-0.5	13.7	-4.6	4.3	14.4	28.6
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	3.4	2.1	1.0	0.3	1.4	0.7	0.3	0.1
133	Path Loss Allocation:									
134	Free Space	dB	132.4	128.3	122.2	110.8	124.9	118.7	110.2	96.8
135	Atmosphere	dB	0.3	0.2	0.1	0.0	0.1	0.1	0.0	0.0
136	Rain	dB	12.4	7.7	3.8	1.0	5.2	2.6	1.0	0.2
137										
138										
139	LMDS Signal: rain Satellite Signal: rain									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig #2					TI #3			
5	Link		Sub to Hub					Hub to Sub			
6	Modulation		QPSK					FM			
7	Digital Data Rate		5 Mbps					N/A			
8	Channel Bandwidth		5.2 MHz					17 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System										
13											
140	ES angle from boresight		5	10	20	48		5	10	20	48
141	*LMDS Boresight*										
142	Required Path Loss	dB	-167.7	-158.8	-148.7	-134.5		-183.3	-174.4	-164.3	-150.1
143	Margin at 1 km (clear sky)	dB	-45.8	-36.9	-26.8	-12.6		-61.4	-52.5	-42.4	-28.2
144	Required Separation (clear sky, no radio horizon)	km	79.3	43.0	18.0	4.1		169.4	114.1	63.8	20.4
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-42.1	-33.2	-23.1	-8.9		-77.7	-48.8	-38.7	-24.5
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	27.2	11.6	4.0	1.9		14.5	46.6	19.9	4.6
147	Path Loss Allocation:										
148	Free Space	dB	150.5	143.1	133.8	127.3		160.3	155.2	147.8	135.1
149	Atmosphere	dB	2.7	1.2	0.4	0.2		8.5	4.7	2.0	0.5
150	Rain	dB	14.5	14.5	14.5	6.9		14.5	14.5	14.5	14.5
151	*LMDS 5 degree Sidelobe*										
152	Required Path Loss	dB	-167.7	-158.8	-148.7	-134.5		-160.9	-152.0	-141.9	-127.7
153	Margin at 1 km (clear sky)	dB	-45.8	-36.9	-26.8	-12.6		-39.0	-30.1	-20.0	-5.8
154	Required Separation (clear sky, no radio horizon)	km	79.3	43.0	18.0	4.1		50.8	24.3	9.1	1.9
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-42.1	-33.2	-23.1	-8.9		-35.3	-26.4	-16.3	-2.1
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	27.2	11.6	4.0	1.9		14.4	6.7	2.9	1.2
157	Path Loss Allocation:										
158	Free Space	dB	150.5	143.1	133.8	127.3		145.0	136.9	131.0	123.2
159	Atmosphere	dB	2.7	1.2	0.4	0.2		1.4	0.6	0.3	0.1
160	Rain	dB	14.5	14.5	14.5	6.9		14.5	14.5	10.6	4.3
161	*LMDS 45 degree Sidelobe*										
162	Required Path Loss	dB	-167.7	-158.8	-148.7	-134.5		-153.3	-144.4	-134.3	-120.1
163	Margin at 1 km (clear sky)	dB	-45.8	-36.9	-26.8	-12.6		-31.4	-22.5	-12.4	1.8
164	Required Separation (clear sky, no radio horizon)	km	79.3	43.0	18.0	4.1		27.4	11.7	4.0	0.8
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-42.1	-33.2	-23.1	-8.9		-27.7	-18.8	-8.7	5.5
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	27.2	11.6	4.0	1.9		6.6	3.3	1.9	0.6
167	Path Loss Allocation:										
168	Free Space	dB	150.5	143.1	133.8	127.3		138.1	132.1	127.2	117.7
169	Atmosphere	dB	2.7	1.2	0.4	0.2		0.7	0.3	0.2	0.1
170	Rain	dB	14.5	14.5	14.5	6.9		14.5	11.9	6.9	2.3
171	*LMDS 180 degree Backlobe*										
172	Required Path Loss	dB	-167.7	-158.8	-148.7	-134.5		-153.3	-144.4	-134.3	-120.1
173	Margin at 1 km (clear sky)	dB	-45.8	-36.9	-26.8	-12.6		-31.4	-22.5	-12.4	1.8
174	Required Separation (clear sky, no radio horizon)	km	79.3	43.0	18.0	4.1		27.4	11.7	4.0	0.8
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-42.1	-33.2	-23.1	-8.9		-27.7	-18.8	-8.7	5.5
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	27.2	11.6	4.0	1.9		6.6	3.3	1.9	0.6
177	Path Loss Allocation:										
178	Free Space	dB	150.5	143.1	133.8	127.3		138.1	132.1	127.2	117.7
179	Atmosphere	dB	2.7	1.2	0.4	0.2		0.7	0.3	0.2	0.1
180	Rain	dB	14.5	14.5	14.5	6.9		14.5	11.9	6.9	2.3

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		TI Dig 3				TI #4			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				AM			
7	Digital Data Rate		5 Mbps				N/A			
8	Channel Bandwidth		5.2 MHz				4.2 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
14	Required Separation (clear sky, incl. 100 km radio horizon)									
15	ES angle from boresight		5	10	20	48	5	10	20	48
16	LMDS receiver pointing angle									
17	Boresight	km	7.2	2.7	0.9	0.2	73.4	38.9	15.9	3.6
18	5 Degree Sidelobe	km	7.2	2.7	0.9	0.2	11.4	4.4	1.4	0.3
19	45 Degree Sidelobe	km	7.2	2.7	0.9	0.2	5.1	1.9	0.6	0.1
20	180 Degree Backlobe	km	7.2	2.7	0.9	0.2	5.1	1.9	0.6	0.1
21										
22	Calculations									
23										
24	LMDS Signal Link Carrier Level at Cell Edge		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
25	Transmitted Power	dBW/channel	-32		-32		-5		-5	
26	Transmitter Antenna Gain	dBi	34		34		12		12	
27	EIRP (clear sky)	dBW/channel	2		2		7		7	
28	Power Control (rain)	dB	0		5		0		5	
29	Distance to Cell Edge	km	1		1		1		1	
30	Rain Attenuation (cell edge)	dB	0		-5		0		-5	
31	Free Space Path Loss (cell edge)	dB	-121.8		-121.8		-121.8		-121.8	
32	Receiver Antenna Gain	dBi	12		12		34		34	
33	Carrier Level at Cell Edge	dBW/channel	-107.8		-107.8		-80.8		-80.8	
34	Notes:									
35	Rain attenuation from WG1/52 (rev. 3)		Antenna gains include pointing loss				Antenna gains include pointing loss			
36	Power control is the minimum necessary to overcome rain fade without exceeding maximum		TI max power control: 12 dB				TI max power control: 12 dB			
37										
38										
39	Interference Density Into LMDS		Clear Sky		Rain Conditions		Clear Sky		Rain Conditions	
40	k (Boltzmann's Constant)	dBW/K/Hz	-228.6		-228.6		-228.6		-228.6	
41	Receiver Noise Figure	dB	8		8		8		8	
42	Receiver Noise Temperature	K	1830		1830		1830		1830	
43	Channel Bandwidth	MHz	5.2		5.2		4.5		4.5	
44	Receiver Noise Floor	dBW/channel	-128.8		-128.8		-129.4		-129.4	
45	Minimum Required C/(N + I)	dB per channel	13		13		45		45	
46	Cell Edge C/N	dB	21.0		21.0		46.6		46.6	
47	Cell Edge C/N	linear	126		126		73011		73011	
48	Required C/(N + I)	linear	20		20		31623		31623	
49	Maximum Acceptable Interference	dBW/channel	-121.6		-121.6		-128.3		-128.3	
50	Maximum Acceptable Interference Density	dBW/Hz	-188.7		-188.7		-194.8		-194.8	
51	Notes:									
52										
53										
54	Interference Density Generated									
55	IRIDIUM Feeder Links Into LMDS Receivers									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94										
2											
3	LMDS System Parameters										
4	System Proponent		TI Dig 3					TI #4			
5	Link		Sub to Hub					Hub to Sub			
6	Modulation		QPSK					AM			
7	Digital Data Rate		5 Mbps					N/A			
8	Channel Bandwidth		5.2 MHz					4.2 MHz			
9	Antenna Pattern Used		Proponent					Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3					9/16/94 Rev 3			
11											
12	Feeder Link System										
13											
56											
57	ES angle from boresight	degrees	5	10	20	48		5	10	20	48
58	Earth Station Output Power (no rain)	dBW/channel	-12.8	-12.8	-12.8	-12.8		-12.8	-12.8	-12.8	-12.8
59	Slant Path Length	km	2741.1	2325.7	1732.4	1006.9		2741.1	2325.7	1732.4	1006.9
60	Power Control (slant path)	dB	1.5	0.0	-2.5	-7.2		1.5	0.0	-2.5	-7.2
61	Antenna Gain	dBi	14.5	7.0	-0.5	-10.0		14.5	7.0	-0.5	-10.0
62	Single Channel BW	MHz	4.375	4.375	4.375	4.375		4.375	4.375	4.375	4.375
63	Number of Interfering Channels	dB	0	0	0	0		0	0	0	0
64	LMDS Receiver Bandwidth	MHz	5.2	5.2	5.2	5.2		4.5	4.5	4.5	4.5
65	Interference Density Subtotal (clear sky)	dBW/Hz	-64.0	-72.9	-83.0	-97.2		-63.4	-72.3	-82.4	-96.6
66	Rain Rate	mm/hr	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
67	Length of rain cell	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
68	Path Length through rain	km	Not Used	Not Used	Not Used	Not Used		Not Used	Not Used	Not Used	Not Used
69	Rain Attenuation	dB	15	15	15	15		15	15	15	15
70	Power Control (rain)	dB	15.0	15.0	15.0	15.0		15.0	15.0	15.0	15.0
71	Interference Density Subtotal (rain on signal path)	dBW/Hz	-49.0	-57.9	-68.0	-82.2		-48.4	-57.3	-67.4	-81.6
72	Notes:										
73	Antenna Gain is the maximum elevation pattern gain in the direction of the LMDS receiver w										
74	the earth station is pointing in the direction of the LMDS receiver										
75	Antenna Gain is 32-25*log(theta)										
76	Power Control (slant path) is the difference in EIRP required to offset the path loss along th										
77	Eb/No at the satellite receiver										
78	The default slant path (0 dB power control) is for a 10 degree elevation angle										
79	Total Power Control (rain plus slant path) cannot exceed 24.8 dB										
80	Interference Density Subtotal calculated based on AWGN assumption										
81	may be a low estimate of interference										
82	Lin Model used for rain attenuation on interference path										
83	Assume rain fade of 15 dB on satellite signal path										
84	Maximum rain cell 4 km long										
85											
86											
87	LMDS Receiver Antenna Gain										
88	Boresight	dBi	15					35			
89	5 Degree Sidelobe	dBi	15					12.6			
90	45 Degree Sidelobe	dBi	15					5			
91	180 Degree Backlobe	dBi	15					5			
92	Note:										
93	Negative margin indicates C/(N + I) objective not met at 1 km separation										
94	All path loss values indicate positive loss (negative gain) regardless of sign										
95	LMDS Signal: clear sky, Satellite Signal: clear sky										
96	ES angle from boresight		5	10	20	48		5	10	20	48
97	LMDS Boresight										

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		TI Dig 3				TI #4			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				AM			
7	Digital Data Rate		5 Mbps				N/A			
8	Channel Bandwidth		5.2 MHz				4.2 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 1/52	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
98	Required Path Loss	dB	-139.7	-130.8	-120.7	-106.5	-166.8	-157.5	-147.4	-133.2
99	Margin at 1 km (clear sky)	dB	-17.8	-8.9	1.2	15.4	-44.8	-35.6	-25.5	-11.3
100	Required Separation (clear sky, no radio horizon)	km	7.2	2.7	0.9	0.2	73.4	38.9	15.9	3.6
101	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-14.1	-5.2	4.9	19.1	-40.8	-31.9	-21.8	-7.6
102	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.6	1.5	0.7	0.2	24.2	10.2	3.8	1.7
103	Path Loss Allocation:									
104	Free Space	dB	130.0	125.2	118.2	105.9	149.5	142.0	133.3	126.6
105	Atmosphere	dB	0.3	0.1	0.1	0.0	2.4	1.0	0.4	0.2
106	Rain	dB	9.4	5.4	2.4	0.6	14.5	14.5	13.7	6.4
107	*LMDS 5 degree Sidelobe*									
108	Required Path Loss	dB	-139.7	-130.8	-120.7	-106.5	-144.1	-135.1	-125.0	-110.8
109	Margin at 1 km (clear sky)	dB	-17.8	-8.9	1.2	15.4	-22.1	-13.2	-3.1	11.1
110	Required Separation (clear sky, no radio horizon)	km	7.2	2.7	0.9	0.2	11.4	4.4	1.4	0.3
111	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-14.1	-5.2	4.9	19.1	-18.4	-9.5	0.6	14.8
112	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.6	1.5	0.7	0.2	3.2	2.0	1.0	0.3
113	Path Loss Allocation:									
114	Free Space	dB	130.0	125.2	118.2	105.9	132.0	127.7	121.4	109.8
115	Atmosphere	dB	0.3	0.1	0.1	0.0	0.3	0.2	0.1	0.0
116	Rain	dB	9.4	5.4	2.4	0.6	11.8	7.2	3.5	0.9
117	*LMDS 45 degree Sidelobe*									
118	Required Path Loss	dB	-139.7	-130.8	-120.7	-106.5	-136.5	-127.5	-117.4	-103.2
119	Margin at 1 km (clear sky)	dB	-17.8	-8.9	1.2	15.4	-14.6	-5.6	4.5	18.7
120	Required Separation (clear sky, no radio horizon)	km	7.2	2.7	0.9	0.2	5.1	1.9	0.6	0.1
121	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-14.1	-5.2	4.9	19.1	-10.8	-1.9	8.2	22.4
122	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.6	1.5	0.7	0.2	2.1	1.2	0.5	0.1
123	Path Loss Allocation:									
124	Free Space	dB	130.0	125.2	118.2	105.9	128.4	123.1	115.6	102.8
125	Atmosphere	dB	0.3	0.1	0.1	0.0	0.2	0.1	0.0	0.0
126	Rain	dB	9.4	5.4	2.4	0.6	7.8	4.3	1.8	0.4
127	*LMDS 180 degree Backlobe*									
128	Required Path Loss	dB	-139.7	-130.8	-120.7	-106.5	-136.5	-127.5	-117.4	-103.2
129	Margin at 1 km (clear sky)	dB	-17.8	-8.9	1.2	15.4	-14.6	-5.6	4.5	18.7
130	Required Separation (clear sky, no radio horizon)	km	7.2	2.7	0.9	0.2	5.1	1.9	0.6	0.1
131	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-14.1	-5.2	4.9	19.1	-10.8	-1.9	8.2	22.4
132	Required Separation (21 mm/hr rain on interference up to 4 km)	km	2.6	1.5	0.7	0.2	2.1	1.2	0.5	0.1
133	Path Loss Allocation:									
134	Free Space	dB	130.0	125.2	118.2	105.9	128.4	123.1	115.6	102.8
135	Atmosphere	dB	0.3	0.1	0.1	0.0	0.2	0.1	0.0	0.0
136	Rain	dB	9.4	5.4	2.4	0.6	7.8	4.3	1.8	0.4
137										
138										
139	LMDS Signal: rain Satellite Signal: rain									

1	Working Group 2: Computation and Modeling Ad Hoc Committee 9/19/94									
2										
3	LMDS System Parameters									
4	System Proponent		TI Dig 3				TI #4			
5	Link		Sub to Hub				Hub to Sub			
6	Modulation		QPSK				AM			
7	Digital Data Rate		5 Mbps				N/A			
8	Channel Bandwidth		5.2 MHz				4.2 MHz			
9	Antenna Pattern Used		Proponent				Proponent			
10	Date/Revision of System Parameters	WG 152	9/16/94 Rev 3				9/16/94 Rev 3			
11										
12	Feeder Link System									
13										
140	ES angle from boresight		5	10	20	48	5	10	20	48
141	*LMDS Boresight*									
142	Required Path Loss	dB	-154.7	-145.8	-135.7	-121.5	-161.5	-172.5	-162.4	-148.2
143	Margin at 1 km (clear sky)	dB	-32.8	-23.9	-13.8	0.4	-59.5	-50.6	-40.5	-26.3
144	Required Separation (clear sky, no radio horizon)	km	31.0	13.5	4.7	1.0	157.2	103.7	56.2	17.1
145	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-29.1	-20.2	-10.1	4.1	-55.8	-46.9	-36.8	-22.6
146	Required Separation (21 mm/hr rain on interference up to 4 km)	km	7.6	3.5	2.0	0.7	75.5	40.4	16.6	3.9
147	Path Loss Allocation:									
148	Free Space	dB	139.5	132.7	128.0	118.8	159.4	153.9	146.2	133.6
149	Atmosphere	dB	0.8	0.3	0.2	0.1	7.6	4.0	1.7	0.4
150	Rain	dB	14.5	12.7	7.5	2.6	14.5	14.5	14.5	14.2
151	*LMDS 5 degree Sidelobe*									
152	Required Path Loss	dB	-154.7	-145.8	-135.7	-121.5	-159.1	-150.1	-140.0	-125.8
153	Margin at 1 km (clear sky)	dB	-32.8	-23.9	-13.8	0.4	-37.1	-28.2	-18.1	-3.9
154	Required Separation (clear sky, no radio horizon)	km	31.0	13.5	4.7	1.0	43.9	20.5	7.5	1.6
155	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-29.1	-20.2	-10.1	4.1	-33.4	-24.5	-14.4	-0.2
156	Required Separation (21 mm/hr rain on interference up to 4 km)	km	7.6	3.5	2.0	0.7	11.9	4.6	2.6	1.0
157	Path Loss Allocation:									
158	Free Space	dB	139.5	132.7	128.0	118.8	143.3	135.1	130.2	121.9
159	Atmosphere	dB	0.8	0.3	0.2	0.1	1.2	0.5	0.3	0.1
160	Rain	dB	14.5	12.7	7.5	2.6	14.5	14.5	9.6	3.8
161	*LMDS 45 degree Sidelobe*									
162	Required Path Loss	dB	-154.7	-145.8	-135.7	-121.5	-151.5	-142.5	-132.4	-118.2
163	Margin at 1 km (clear sky)	dB	-32.8	-23.9	-13.8	0.4	-29.5	-20.6	-10.5	3.7
164	Required Separation (clear sky, no radio horizon)	km	31.0	13.5	4.7	1.0	23.2	9.7	3.3	0.7
165	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-29.1	-20.2	-10.1	4.1	-25.8	-16.9	-6.8	7.4
166	Required Separation (21 mm/hr rain on interference up to 4 km)	km	7.6	3.5	2.0	0.7	5.4	3.0	1.7	0.5
167	Path Loss Allocation:									
168	Free Space	dB	139.5	132.7	128.0	118.8	136.4	131.3	126.2	116.2
169	Atmosphere	dB	0.8	0.3	0.2	0.1	0.5	0.3	0.2	0.1
170	Rain	dB	14.5	12.7	7.5	2.6	14.5	10.9	6.1	1.9
171	*LMDS 180 degree Backlobe*									
172	Required Path Loss	dB	-154.7	-145.8	-135.7	-121.5	-151.5	-142.5	-132.4	-118.2
173	Margin at 1 km (clear sky)	dB	-32.8	-23.9	-13.8	0.4	-29.5	-20.6	-10.5	3.7
174	Required Separation (clear sky, no radio horizon)	km	31.0	13.5	4.7	1.0	23.2	9.7	3.3	0.7
175	Margin at 1 km (3.7 dB rain attenuation on interference)	dB	-29.1	-20.2	-10.1	4.1	-25.8	-16.9	-6.8	7.4
176	Required Separation (21 mm/hr rain on interference up to 4 km)	km	7.6	3.5	2.0	0.7	5.4	3.0	1.7	0.5
177	Path Loss Allocation:									
178	Free Space	dB	139.5	132.7	128.0	118.8	136.4	131.3	126.2	116.2
179	Atmosphere	dB	0.8	0.3	0.2	0.1	0.5	0.3	0.2	0.1
180	Rain	dB	14.5	12.7	7.5	2.6	14.5	10.9	6.1	1.9

ADDENDA

Addenda are provided by Committee members desiring to include a separate statement, materials, or other matters with the Committee's Report. The following parties have provided the additional materials included herein:

Bell Communications Research (on behalf of Ameritech, BellSouth, and Pacific Telesis Group)

Constellation Communications, Inc., Loral/QUALCOMM Partnership, L.P., Mobile Communications Holdings, Inc., and TRW, Inc., filing jointly

Educational and Public Telecommunications Entities (a complete list of these entities is included with their addendum)

Harris Corporation -- Farinon Division and Digital Microwave Corporation, filing jointly (2 documents)

Hughes Space and Communications Company and Hughes Communications Galaxy, Inc.

International CellularVision Association

International Communications Engineering Group

Martin Marietta Astro Space

National Aeronautics and Space Administration (Lewis Research Center) and mm-Tech, Inc.

National Aeronautics and Space Administration

NRMC Members Supporting Motorola-Suite 12/CVNY Rule Proposal

NYNEX Science & Technology, Inc.

RioVision of Texas, Inc.

Suite 12/CellularVision of New York, L.P. (2 documents)

Teledesic Corporation

TRW, Inc.

Video/Phone Systems, Inc.

Interference from FSS Uplinks into LMDS Receivers: The Impact of Improved Antenna Patterns

Contact:
Dr. Scott Y. Seidel
Bell Communications Research
331 Newman Springs Road
Red Bank, New Jersey 07701
908-758-2928
fax: 908-758-4371

Abstract

This paper investigates the impact of the FSS earth station uplink antenna pattern on the required separation distance between FSS uplink earth stations and LMDS receivers. It is shown that a decrease in earth station antenna sidelobe levels along the horizon can reduce the required separation distance between the terminals under both clear sky and rain conditions by up to one or two orders of magnitude for the scenarios considered here. In fact, Table 2 shows *typical* separations of 100 feet (0.02 miles) at 45 degree LMDS sidelobes may be possible. A reduction in required separation distance corresponds to a decrease in the size of the LMDS cell area where interference is received from an individual FSS earth station. A list of additional factors that may contribute to actual received interference levels lower than the values in the calculations is presented. An explanation is given of how each factor could reduce the interference. Factors that may limit the amount of interference reduction are also discussed. Future studies on co-frequency sharing are suggested to examine the impact of factors not included in previous calculations.

1.0 Introduction and Summary of Results

Interference calculations performed as part of the 28 GHz Negotiated Rule-Making Committee (NRMC) deliberations on interference from FSS satellite uplinks into LMDS receivers showed significant potential for interference. Improved antenna sidelobe performance was one of the mitigation opportunities identified to reduce the level of this potential interference. In order to be very confident that its interference study results were achievable, the Committee agreed during one of its working group meetings to use information on antennas that had been built and tested rather than those on which only design information was available. Where measured antenna range pattern information was not available, ITU masks were to be used as a default; for FSS satellite uplinks, these patterns were specified as the ITU-699 mask. With these guidelines in place, NRMC calculations were performed using antenna patterns submitted by each of the FSS and LMDS proponents. In addition to the analyses performed by the NRMC using these conservative guidelines, it is important to continue to explore potential mitigation that would be achieved by antenna designs that are thought to be theoretically sound and potentially achievable. Contribution NRMC/104, "Comments Concerning Earth Station to LMDS Interference Predictions," submitted by antenna manufacturer Andrew Corp., indicates that antenna improvements on the order of 20-45 dB for off-axis angles between 30-90 degrees may be possible. Since contribution NRMC/104 was one of the many documents introduced to the Committee near the end of its negotiation period, and it therefore did not have a chance to discuss this contribution, a preliminary study of the impact of improved sidelobe levels on co-frequency sharing was undertaken. Calculations presented here show how improved sidelobe levels on the earth station (ES) uplink antennas can be used to reduce the magnitude of the interference problem. The feasibility of obtaining these reduced sidelobe levels is not addressed; a determination of the technical and economic feasibility should be addressed by the antenna manufacturing community and potential users of these antennas.

Results of the analysis presented here indicate that, for the situations studied, application of improved earth station sidelobes as a mitigation technique could typically reduce the previously calculated separation distances by one or two orders of magnitude, depending on the extent of the sidelobe performance that could be achieved. Boresight separation, for example, could potentially be decreased from 28.18 miles to 1.80 or 0.32 miles for the two antenna sidelobe performance improvement scenarios studied. The area of an LMDS cell where an FSS uplink would cause interference would be reduced by improvement in FSS earth station antenna sidelobe discrimination.

2.0 Description of Calculations

2.1 Background

The spreadsheet used to calculate the interference from MSS feeder links into LMDS receivers for the Working Group 2 section of the NRMC final report was modified to allow calculation of interference from FSS uplinks into LMDS receivers. The LMDS system parameters in the appendix to the Working Group 1 Report are used in the calculations. The Teledesic system parameters are derived from Figures 6.2-1 and 6.2-2 in the Working Group 1 Report. Calculations are made for a T1 Teledesic Standard Terminal (TST) interfering into LMDS hub and subscriber receivers for representative system parameters provided by the system proponents. These representative cases were chosen to investigate the magnitude of interference reduction when improved earth