LMDS AGGREGATE INTERFERENCE INTO POCS RECEIVERS

To estimate the amount of aggregate interference introduced into proximity operations space receivers, a MATLAB computer simulation program was developed. Space system receiver input parameters are:

1) Space Station altitude (assumed to be 350 km)
2) Receive HPBW (assumed to be 5.9°)
3) Receive antenna gain (assumed to be 32.55 dBi)
4) Receive system noise temperature (assumed to be 733°K)
5) Receive system bandwidth (14.7 MHZ in most cases)

LMDS system input parameters are:

1) Max EIRP (at cell edge for subscribers)
2) Transmit signal bandwidth
3) LMDS cell radius
4) Height of hub above ground level
5) Maximum pointing elevation of subscriber antennas
6) Hub antenna mainbeam elevation angle (since hubs are typically pointed slightly downward)
7) Modulation peaking factor (for the case of a wideband interferer into a narrowband receiver)
8) Rain climate zone (consistent with the cell size above)
9) Number of simultaneous co-frequency subscribers per cell (assumed to be one for all systems except ENDGATE which uses a 36-sectorized cell)
10) Frequency interleaving (assumed to be -3 dB for CV and 0 for all others)

Additionally, 3 dB beam footprint areas for various beam aimpoint elevation angles are input to the simulation. These footprint areas were pre-calculated off-line using a separate program since they involve a significant amount of computation by their own right.

A "FILL" vector specifying various LMDS beam fill percentages and the areas of selected MSAs (metropolitan statistical areas) are also input to the simulation. These variables are used to compute the "effective LMDS area" which is defined to be that area occupied by LMDS cells. This is to take into account the fact that beam footprints (especially large ones that occur at low elevation angles) will typically not be completely saturated with LMDS systems. The program provides three options for computing effective area. These are described below with the aid of the following figure.

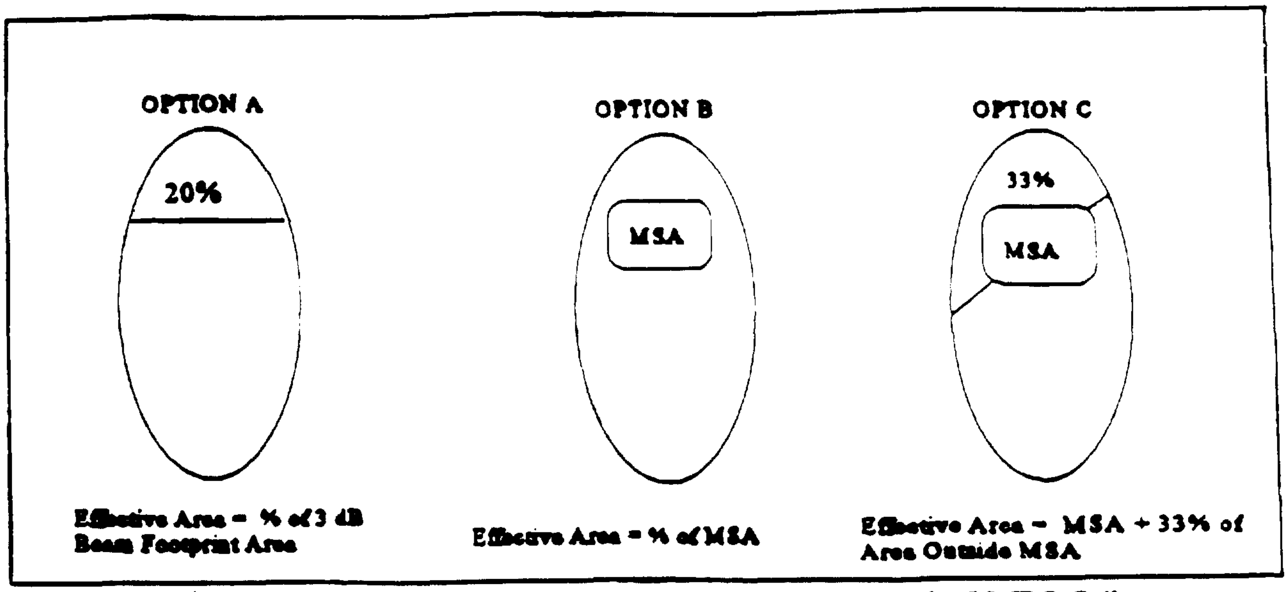


Figure 1. Options for Computing Effective Area Occupied by LMDS Cells

Option A uses the % fill values to simply calculate the effective area as a specified percentage of the 3 dB beam footprint area. For example, a fill percentage of 20% would take the effective area as 20% of the footprint area. The approximate number of LMDS cells in the footprint is then found by dividing the effective area by the LMDS cell area.

In option B, the fill percentage is interpreted as a certain percentage of the MSA area. For example, a fill percentage of 100% would take the effective area to be the entire MSA area *as long as the beam footprint is larger than the MSA.* The rest of the footprint is assumed to be completely empty of LMDS cells. *If the beam footprint, on the other hand, is smaller than the MSA itself, the effective area is taken to be equal to the beam area even if a 100% MSA coverage is specified.* This typically happens at higher elevation angles.

Option C is similar and is analogous to the Canadian approach for computing effective area. Again, if the beam footprint is larger than the MSA (as shown in the figure), and 100% MSA coverage is specified, the effective area is taken to be the entire MSA + *33% of the remaining footprint area outside the MSA.* Like option B, however, if the beam footprint is smaller than the MSA, then the effective area is simply taken to be the beam footprint area itself. Again, this typically occurs at the higher elevation angles. Hence, at the higher elevation angles, the I/N margin values for a particular scenario will generally be the same for both Options B and C.

Once the LMDS effective area is calculated according to one of the three options above, the approximate number of LMDS cells in the beam footprint is found by dividing the effective area by the cell area. For subscriber interference, the number of co-channel interferers per cell whose carriers fall into the POCS receive bandwidth is then found by comparing the receiver bandwidth with the interferer's bandwidth. For example, an LMDS scenario in which an individual subscriber's bandwidth is 1 MHZ (for a T1 data rate) and the space system receive bandwidth is 14.7 MHZ, will assume 15 subscriber interferers per cell. In addition, if there is frequency reuse within the cell by means of sectorization (as in the case of ENDGATE with 36 sectors), the number of potential interferers per cell is further multiplied by this factor.

For the estimated number of LMDS cells in the footprint (NCELL), the program then populates the footprint with cells starting at the far edge of the footprint and progressing towards the near edge. For each cell, the elevation angle to the satellite is computed as well as the gain fall-off at the satellite antenna. The atmospheric loss for each cell is also calculated based on its elevation angle and the specified rain-climate zone. Because the cell sizes are much smaller than the distance to the satellite, all subscribers within a cell are assumed to have the same satellite elevation angle, atmospheric loss, and gain fall-off at the satellite as that computed for the particular cell itself. (Note, however, that pointing angles and gain falloffs at the subscriber antenna are computed for every subscriber in every cell.) At this point, the algorithm branches into two separate paths depending on whether subscribers or hubs are being analyzed. Since subscriber interference is more complicated, the rest of this description pertains only to subscriber analysis, although the hub analysis is very similar.

After populating the footprint with the appropriate number of cells, the interferers within a cell are randomly located within each cell. For example, for the case described above with 15 T1 interferers per cell, 15 interferers would be randomly distributed in each of the NCELL cells within the footprint. (Note that in some cases as seen in the table, one interferer per cell is deliberately forced into azimuth alignment with the satellite to study its effect.). After the subscribers have been randomly distributed in the cells, a number of parameters are calculated for each subscriber. These are:

1) Subscriber-to-hub ranges within each cell
2) Subscriber EIRP as a function of subscriber-to-hub distance
3) Subscriber antenna elevation angle based on distance to hub and hub height above ground level
4) Off-axis angle of each subscriber's antenna pointing direction (towards the hub) from its line-of-sight to the satellite
5) Using the off-axis angles in (4) and the specified subscriber antenna pattern, the corresponding subscriber antenna gain falloffs are computed
6) The subscriber antenna gain falloffs are checked to see which ones are less than 3 dB. Where this occurs, it indicates main-beam coupling and a 3 dB polarization discrimination is assumed.
7) The slant range and free-space loss are computed for each subscriber
8) The interference power at the satellite is computed from each subscriber transmitter in each of the NCELLS taking into account extra factors such as interleaving, peaking, and bandwidth adjustment (for a wideband interferer into a narrowband receiver) where they apply.
9) After converting the individual interfering powers from dB to non-dB units (Watts), the aggregate interference power is computed by summing over all subscriber interference powers.
10) The thermal noise power N in dBW is subtracted from the aggregate interference power I in dBW to get the I/N ratio.
11) The I/N ratio is compared with the I/N criterion of -6 dB to get the margin.

This procedure is repeated for each of the specified beam footprint areas and % coverage values.

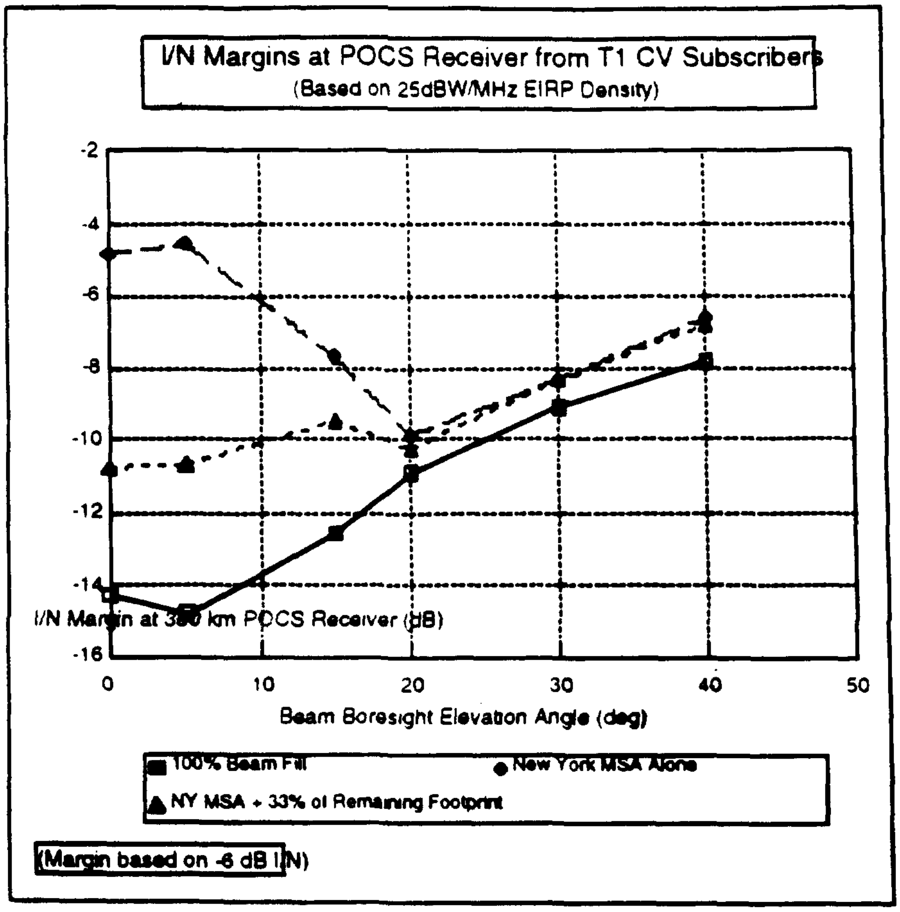

I/N Margins at POCS Receiver from T1 CV Subscribers
(Based on 25dBW/MHz EIRP Density)
I/N Margin at 380 km POCS Receiver (dB)
Beam Boresight Elevation Angle (deg)
100% Beam Fill
New York MSA Alone
NY MSA + 33% of Remaining Footprint
(Margin based on -6 dB I/N)

Fig B1

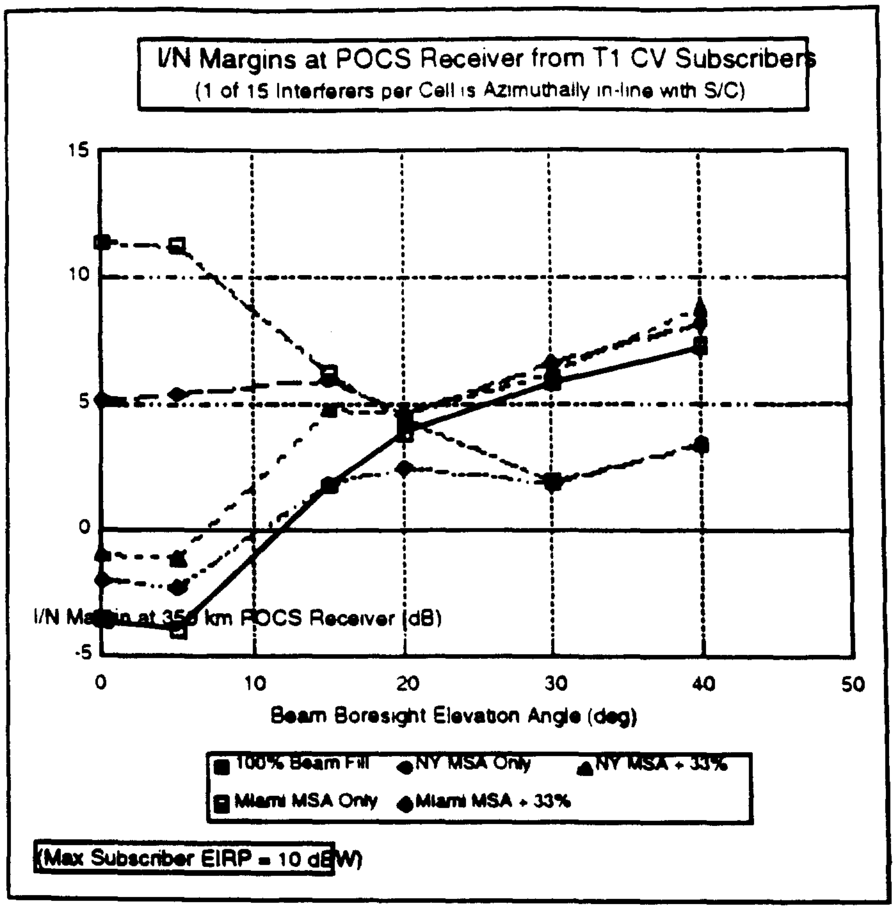

I/N Margins at POCS Receiver from T1 CV Subscribers
(1 of 15 Interferers per Cell is Azimuthally in-line with S/C)
15
10
5
0
-5
I/N Margin at 350 km POCS Receiver (dB)
0
10
20
30
40
50
Beam Boresight Elevation Angle (deg)
100% Beam Fill
NY MSA Only
NY MSA + 33%
Miami MSA Only
Miami MSA + 33%
(Max Subscriber EIRP = 10 dBW)

Fig 32

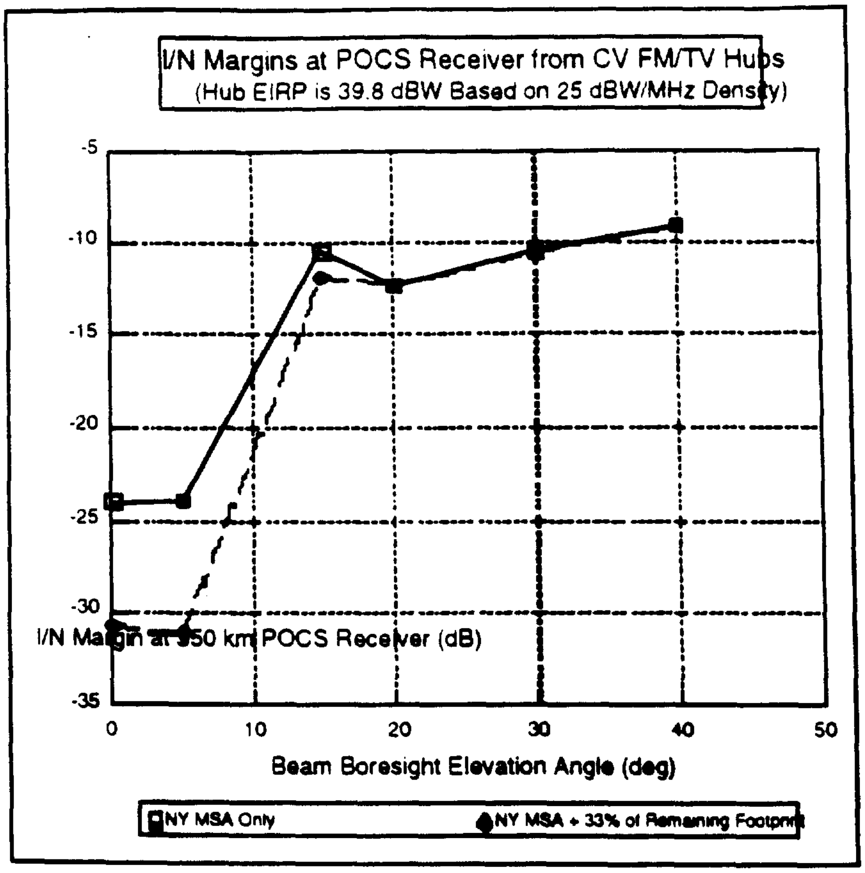
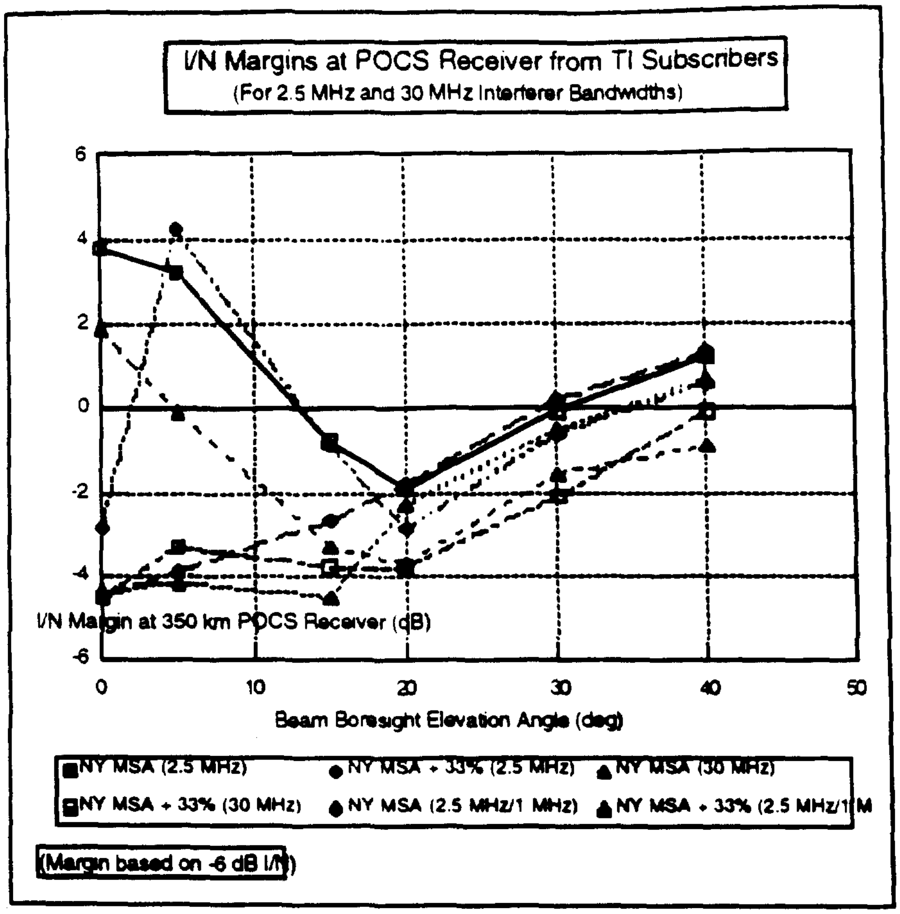
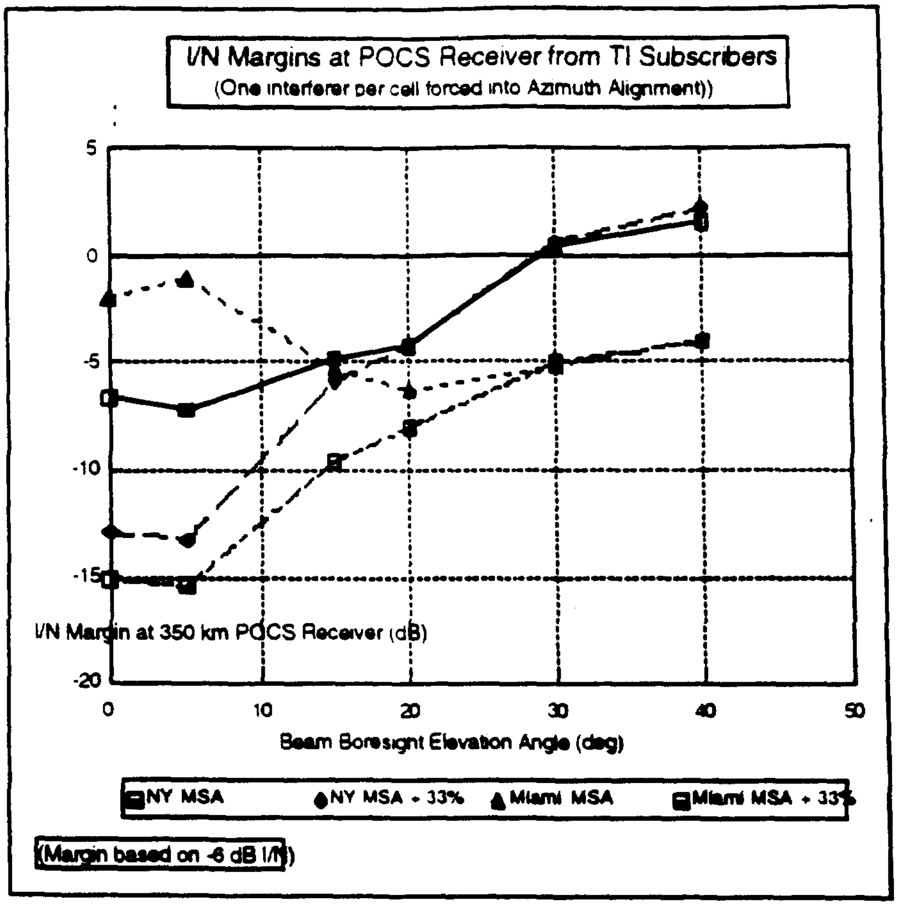

I/N Margins at POCS Receiver from CV FM/TV Hubs
(Hub EIRP is 39.8 dBW Based on 25 dBW/MHz Density)
-5
-10
-15
-20
-25
-30
-35
I/N Margin at 950 km POCS Receiver (dB)
0
10
20
30
40
50
Beam Boresight Elevation Angle (deg)
NY MSA Only
NY MSA + 33% of Remaining Footprint

Fig B3



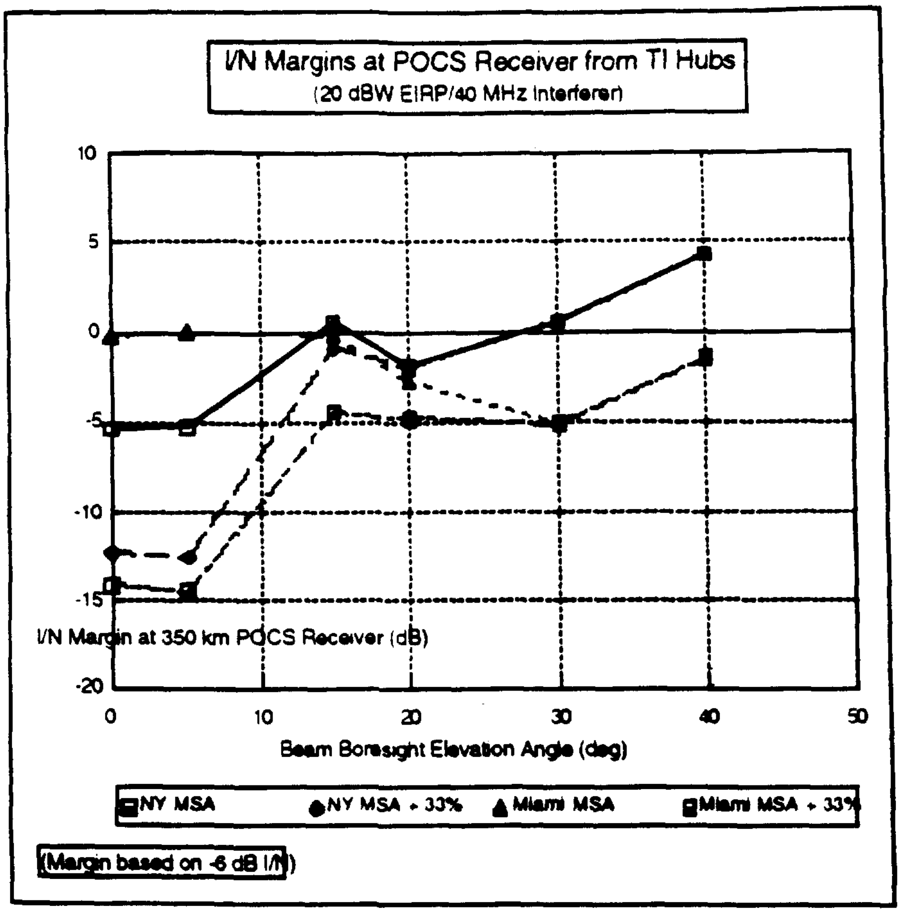
I/N Margins at POCS Receiver from TI Subscribers
(For 2.5 MHz and 30 MHz Interferer Bandwidths)
6
4
2
0
-2
-4
-6
I/N Margin at 350 km POCS Receiver (dB)
0
10
20
30
40
50
Beam Boresight Elevation Angle (deg)
NY MSA (2.5 MHz)
NY MSA + 33% (2.5 MHz)
NY MSA (30 MHz)
NY MSA + 33% (30 MHz)
NY MSA (2.5 MHz/1 MHz)
NY MSA + 33% (2.5 MHz/1 M
(Margin based on -6 dB I/N)

Fig B4



I/N Margins at POCS Receiver from TI Subscribers
(One interferer per cell forced into Azimuth Alignment))
5
0
-5
-10
-15
-20
I/N Margin at 350 km POCS Receiver (dB)
0
10
20
30
40
50
Beam Boresight Elevation Angle (deg)
NY MSA
NY MSA + 33%
Miami MSA
Miami MSA + 33%
(Margin based on -6 dB I/N)

Fig B5


I/N Margins at POCS Receiver from TI Hubs
(20 dBW EIRP/40 MHz Interferer)
10
5
0
-5
-10
-15
-20
I/N Margin at 350 km POCS Receiver (dB)
0
10
20
30
40
50
Beam Boresight Elevation Angle (deg)
NY MSA
NY MSA + 33%
Miami MSA
Miami MSA + 33%
(Margin based on -6 dB I/N)

F8 B6

CV LMDS INTERFERENCE INTO SPACE STATION PROX OPS RECEIVER (350 KM ALTITUDE; 5.9° RECV BEAM HPBW)																
CASE #	SYSTEM	SUB/HUB	MAX EIRP (dBW)	Xmit BW Data Rate	Cell Radius (km)	Rain Zone	Recv BW (MHz)	# of intfers per cell	# AZ aligned with S/C per cell	MSAs	I/N Margins (dB) at Beam Elevation Angle for 100% Coverage of SMA (or beam if so indicated)					
											0°	5°	15°	20°	30°	40°
1	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7MHz	15	0	100% of Beam	0.8	-0.2	2.3	4.3	5.9	7.8
2	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	1	100% of Beam	-3.6	-4.0	1.8	3.9	5.9	7.3
3	CV	SUB	25.0	1 MHz/T1	4.8	2	14.7MHz	15	0	100% of Beam	-14.3	-14.8	-12.6	-10.9	-9.1	-7.8
4	CV	SUB	10.0	1 MHz/T1	2.7	1	14.7 MHz	15	0	100% of Beam	-2.6	-3.4	-1.9	-0.4	1.4	3.0
5	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	0	New York	11.7	11.8	6.8	4.9	6.8	8.4
6 (33%)[1]	CV	SUB	10.0	1 MHz /T1	4.8	2	14.7MHz	15	0	New York	4.8	3.9	5.4	4.8	7.0	8.3
7	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7MHz	15	1	New York	5.2	5.4	6.0	4.6	6.6	8.2
8 (33%)	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	1	New York	-0.9	-1.1	4.8	4.6	6.2	8.8
9	CV	SUB	25.0	1 MHz/T1	4.8	2	14.7 MHz	15	0	New York	-4.8	-4.5	-7.7	-9.9	-8.3	-6.6
10(33%)	CV	SUB	25.0	1 MHz/T1	4.8	2	14.7 MHz	15	0	New York	-10.8	-10.7	-9.5	-10.3	-8.3	-6.8

[1] Cases marked 33% refer to the method in which the effective area within the beam footprint area is calculated. The effective area is assumed to be that area occupied by LMDS cells. For cases marked (33%), the effective area is equal to the beam area if the beam area is less than or equal to the quantity (%coverage*A_{SMA}) which is the percent LMDS coverage (in terms of area) of the indicated SMA (statistical metropolitan area). If the beam area is greater than this quantity, then the effective area is taken to be this quantity + 33% of the beam area outside this area (i.e. A_{EFF} = (%coverage*A_{SMA}) + 0.33*(A_{BEAM}-%coverage*A_{SMA})). For cases not marked (33%), A_{EFF} = A_{BEAM} for A_{BEAM}<=%coverage*A_{SMA} and A_{EFF}=%coverage*A_{SMA} for beam areas greater than %coverage*SMA (i.e. the rest of the beam area is assumed to be empty of LMDS cells)

Table 13 1

11	CV	SUB	10.0	1 MHz/T1	2.7	1	14.7 MHz	15	0	Miami	17.5	17.2	7.0	5.0	2.2	3.7
12(33%)	CV	SUB	10.0	1 MHz/T1	2.7	1	14.7 MHz	15	0	Miami	3.4	2.9	2.9	2.7	1.9	3.8
13	CV	SUB	10.0	1 MHz/T1	2.7	1	14.7 MHz	15	1	Miami	11.4	11.2	6.2	4.4	2.0	3.4
14(33%)	CV	SUB	10.0	1 MHz/T1	2.7	1	14.7 MHz	15	1	Miami	-2.0	-2.3	1.9	2.5	1.9	3.5
15	CV	SUB	5.0	10 kHz/16 kbps	4.8	2	500 kHz	50	0	New York	-3.7	-4.6	-8.0	-10.0	-8.0	-6.4
16(33%)	CV	SUB	5.0	10 kHz/16 kbps	4.8	2	500 kHz	50	0	New York	-10.3	-10.6	-9.6	-10.1	-8.1	-6.7
17	CV	SUB	39.8	30 MHz/45 Mbps	4.8	2	14.7 MHz	1	0	New York	-4.7	-2.2	-8.7	-11.1	-8.3	-6.1
18 (33%)	CV	SUB	39.8	30 MHz/45 Mbps	4.8	2	14.7 MHz	1	0	New York	-10.2	-11.8	-10.1	-10.2	-7.1	-6.0
19	CV	HUB	7.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York	6.8	7.0	20.4	18.7	20.3	21.8
20 (33%)	CV	HUB	7.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York	0.2	0.0	19.1	18.7	20.3	21.8
21	CV	HUB	38.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York	-24.1	-24.0	-10.6	-12.3	-10.6	-9.2
22 (33%)	CV	HUB	38.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York	-30.8	-31.1	-11.9	-12.3	-10.6	-9.2
23	CV	HUB	7.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York+ Phila+ Wash DC	1.3	1.3	–	–	–	–
24 (33%)	CV	HUB	7.0	20 MHz FM/TV	4.8	2	14.7 MHz	1	0	New York + Phila + DC	-1.4	-1.6	–	–	–	–
25	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	0	New York + Phila + DC	5.4	4.9	–	–	–	–
26 (33%)	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	0	New York + Phila + DC	2.9	2.7	–	–	–	–

Table B2

27	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	1	New York + Phila + DC	-0.1	0.1	_	_	_	_
28 (33%)	CV	SUB	10.0	1 MHz/T1	4.8	2	14.7 MHz	15	1	New York + Phila + DC	-2.4	-2.4	_	_	_	_
29 (33%)	CV	HUB(scatter)	7.0	20MHz/FMTV	4.8	2	14.7MHz	1	0	New York	-2.8	-3.1	12	10.7	12.4	13.5
30(33%)	CV	HUB	7.0	20MHz/FMTV (with 10 dB peaking)	4.8	2	1MHz/T1	1	0	New York	-9.8	-10.1	9.1	8.7	10.4	11.8
31	CV	SUB	-10.0	10kHz/16kbps	4.8	2	500kHz	50	0	New York	10.8	10.8	7.1	5.1	7.0	8.6
32(33%)	CV	SUB	-10.0	10kHz/16 kbps	4.8	2	500kHz	50	0	New York	4.7	4.3	5.5	4.9	6.9	8.2
33	CV	SUB	24.8	30MHz/45Mbps	4.8	2	14.7MHz	1	0	New York	10.8	7.7	6.6	5.6	7.0	8.8
34(33%)	CV	SUB	24.8	30MHz/45Mbps	4.8	2	14.7	1	0	New York	6.9	2.3	5.6	5.7	6.4	8.3

Table B3

TI LMDS INTERFERENCE INTO SPACE STATION PROX OPS RECEIVER (350 KM ALTITUDE; 5.9° RECV BEAM HPBW)

CASE #	SYSTEM	SUB/HUB	MAX EIRP (dBW)	Xmit BW Data Rate	Cell Radius (km)	Rain Zone	Recv BW (MHz)	# of intfers per cell	# AZ aligned with S/C	MSAs	I/N Margins (dB) at Beam Elevation Angle for 100% Coverage of SMA[1]					
									per cell		0°	5°	15°	20°	30°	40°
1	TI	SUB	20.0	2.5 MHz/3.3 Mbps	5.0	2	14.7	5	0	New York	3.8	3.2	-0.8	-1.9	-0.1	1.2
2 (33%)[2]	TI	SUB	20.0	2.5MHz/3.3Mbps	5.0	2	14.7	5	0	New York	-4.5	-3.9	-2.7	-1.8	0.2	1.3
3	TI	SUB	20.0	2.5 MHz/3.3Mbps	5.0	2	14.7	5	1	New York	-6.6	-7.1	-4.8	-4.2	0.5	1.6
4 (33%)	TI	SUB	20.0	2.5 MHz/3.3Mbps	5.0	2	14.7	5	1	New York	-12.9	-13.3	-5.8	-4.2	0.6	2.3
5	TI	SUB	20.0	2.5 MHz/3.3Mbps	2.5	1	14.7	5	0	Miami	7.8	7.5	-2.1	-3.4	-5.5	-4.5
6 (33%)	TI	SUB	20.0	2.5 MHz/3.3Mbps	2.5	1	14.7	5	0	Miami	-6.2	-5.4	-6.3	-5.3	-5.6	-4.5
7	TI	SUB	20.0	2.5 MHz/3.3Mbps	2.5	1	14.7	5	1	Miami	-1.9	-1.1	-5.2	-6.3	-5.1	-3.9
8 (33%)	TI	SUB	20.0	2.5 MHz/3.3Mbps	2.5	1	14.7	5	1	Miami	-15.1	-15.4	-9.6	-8.0	-5.0	-4.0
9	TI	SUB	32.0	30 MHz/40 Mbps	5.0	2	14.7	1	0	New York	1.9	-0.1	-3.3	-3.7	-1.6	-0.9
10(33%)	TI	SUB	32.0	30 MHz/40 Mbps	5.0	2	14.7	1	0	New York	-4.5	-3.3	-3.8	-3.8	-2.1	-0.1

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[1] Note that in some cases as described in footnote 2 below, the entire SMA area may not be covered simply because the beam footprint itself is smaller than the SMA area. This is usually true at the higher beam elevations. The footprint areas for the indicated elevations are: 141540km^2(0°); 151300km^2(5°); 39900km^2(15°); 19587km^2(20°); 7212km^2(30°); and 3612km^2(40°). For comparison, the areas of the MSAs are: 19825km^2(New York); 8196km^2(Miami); and 50702km^2 (New York + Philadelphia + Wash D.C. MSAs combined). Also, where the footprint area is larger than the SMA area and the 33% rule is assumed, the area occupied by LMDS cells is considered to be the SMA area + 33% of the area remaining in the footprint.

[2] Cases marked 33% refer to the method in which the effective area within the beam footprint area is calculated. The effective area is assumed to be that area occupied by LMDS cells. For cases marked (33%), the effective area is equal to the beam area if the beam area is less than or equal to the quantity ($\%coverage*A_{SMA}$) which is the percent LMDS coverage (in terms of area) of the indicated SMA (statistical metropolitan area). If the beam area is greater than this quantity, then the effective area is taken to be this quantity + 33% of the beam area outside this area (i.e. $A_{EFF} = (\%coverage*A_{SMA}) + 0.33*(A_{BEAM} - \%coverage*A_{SMA})$). For cases not marked (33%), $A_{EFF} = A_{BEAM}$ for $A_{BEAM} <= \%coverage*A_{SMA}$ and $A_{EFF} = \%coverage*A_{SMA}$ for beam areas greater than %coverage*SMA (i.e. the rest of the beam area is assumed to be empty of LMDS cells)

Table 134

11 (33%)	TI	SUB	32.0	30 MHz/40 Mbps	2.5	1	14.7	1	0	Miami	-7.9	-7.0	-8.5	-7.2	-7.4	-6.6
12(33%)	TI	SUB	32.0	30 MHz/40 Mbps	5.0	2	14.7	1	0	NY+PHILA +DC	-6.7	-8.7	–	–	–	–
14 (33%)	TI	SUB	20.0	2.5 MHz/3.3Mbps	5.0	2	14.7	5	0	NY+PHILA +DC	-5.8	-5.7	–	–	–	–
15	TI	HUB	20.0	40 MHz/65 Mbps	5.0	2	14.7	1	0	New York	-5.4	-5.2	0.6	-2.0	0.6	4.3
16 (33%)	TI	HUB	20.0	40 MHz/65 Mbps	5.0	2	14.7	1	0	New York	-12.3	-12.6	-0.9	-2.0	0.6	4.3
17	TI	HUB	20.0	40 MHz/65 Mbps	2.5	1	14.7	1	0	Miami	-0.2	-.05	-.24	-2.8	-5.1	-1.5
18 (33%)	TI	HUB	20.0	40 MHz/65 Mbps	2.5	1	14.7	1	0	Miami	-14.1	-14.5	-4.4	-4.8	-5.1	-1.5
19	TI	HUB	25.0	60 MHz/200 Mbps	5.0	2	14.7	1	0	New York	-8.6	-8.5	-2.7	-5.3	-2.7	1.0
20 (33%)	TI	HUB	25.0	60 MHz/200Mbps	5.0	2	14.7	1	0	New York	-15.6	-15.9	-4.2	-5.3	-2.7	1.0
21	TI	HUB	25.0	60 MHz/200Mbps	2.5	1	14.7	1	0	Miami	-3.4	-3.3	-3.5	-6.1	-8.4	-4.7
22 (33%)	TI	HUB	25.0	60MHz/200Mbps	2.5	1	14.7	1	0	Miami	-17.3	-17.8	-7.6	-8.1	-8.4	-4.7
23 (33%)	TI	HUB	20.0	40 MHz/65 Mbps	5.0	2	14.7	1	0	NY+PHILA +DC	-14.1	-14.3	–[3]	–	–	–
24 (33%)	TI	HUB	25.0	60MHz/200Mbps	5.0	2	14.7	1	0	NY+PHILA +DC	-17.3	-17.5	–	–	–	–
25(33%)	TI	HUB with scattering	20.0	40MHz/65Mbps	5.0	2	14.7	1	0	New York	-12.3	-12.6	-0.9	-2.0	0.6	4.3
26	TI	SUB	20.0	2.5MHz/3.3Mbps	5.0	2	1MHz	1	0	New York	-2.9	4.2	-0.9	-2.9	-0.6	0.6
27(33%)	TI	SUB	20.0	2.5MHz/3.3Mbps	5.0	2	1MHz	1	0	New York	-4.4	-4.2	-4.5	-2.3	-0.5	0.7

[3] Values are not given for these beam elevations since the footprint does not encompass all three MSAs

TABLE B5

ENDGATE LMDS INTERFERENCE INTO SPACE STATION PROX OPS RECEIVER (350 KM ALTITUDE; 5.9° RECV BEAM HPBW)																
CASE #	SYSTEM	SUB/HUB	MAX EIRP (dBW)	Xmit BW Data Rate	Cell Radius (km)	Rain Zone	Recv BW (MHz)	# of intfers per cell	# AZ aligned with S/C per cell	MSAs	I/N Margins (dB) at Beam Elevation Angle for 100% & 33% beam fill					
											0°	5°	15°	20°	30°	40°
1	EG	SUB	5.0	29.2MHz/45Mbps	7.6	2	14.7	36[1]	0	100%	16.0	16.1	25.9	27.5	30.1	31.4
2	EG	SUB	5.0	29.2MHz/45Mbps	7.6	2	14.7	36	0	33%	18.2	19.1	31.7	33.1	35.8	36.9
3	EG	SUB	-10.0	1 MHz/T1	7.6	2	2 MHz	72	0	100%	17.4	17.0	26.2	27.8	30.4	32.1
4	EG	SUB	-10.0	1MHz/T1	7.6	2	2 MHz	72	0	33%	17.9	18.2	32.2	37.3	36.0	37.2
5	EG	SUB	-10.0	1MHz/T1	7.6	2	1 MHz	36	0	100%	17.9	16.8	26.1	27.8	30.2	32.1
6	EG	SUB	-10.0	1MHz/T1	7.6	2	1 MHz	36	0	33%	18.6	19.6	32.3	33.5	35.9	37.9
7	EG	SUB	-10.0	1MHz/T1	4.5	1	1 MHz	36	0	100%	15.2	14.3	22.1	27.8	26.2	27.9
8	EG	SUB	-10.0	1 MHz/T1	4.5	1	1 MHz	36	0	33%	18.2	17.2	28.4	29.4	31.8	33.7
9	EG	HUB	11.5	29.2MHz/45Mbps	7.6	2	14.7	1	0	100%	-2.2	-2.1	27.1	32.5	39.1	43.3
10	EG	HUB	11.5	29.2MHz/45Mbps	4.5	1	14.7	1	0	100%	-3.1	-3.1	23.2	28.3	34.8	38.9
11	EG	HUB with scattering	11.5	29.2MHz/45Mbps	4.5	1	14.7	1	0	100%	-3.1	-3.2	23.2	26.6	28.2	29.3

[1]ENDGATE uses a sectorized hub wherein the cell is divided into separate 10° sectors (36 sectors in the cell) with the frequency being reused within each sector. Adjacent sectors operate on opposite linear polarizations in order to provide discrimination at the receivers. The number of co-channel interferers per cell (in the case of subscribers) is therefore the victim receive bandwidth/interferer bandwidth x 36. Since the space receiver is assumed to operate on circular polarization and out linear polarization interference can be removed from all sectors in a cell

TABLE B6

HP LMDS INTERFERENCE INTO SPACE STATION PROX OPS RECEIVER (350 KM ALTITUDE; 5.9° RECV BEAM HPBW)																
CASE #	SYSTEM	SUB/HUB	MAX EIRP (dBW)	Xmit BW/ Data Rate	Cell Radius (km)	Rain Zone	Recv BW (MHz)	# of intfers per cell	# AZ aligned with S/C	MSAs	I/N Margins (dB) at Beam Elevation Angle for Indicated Coverage[1]					
									per cell		0°	5°	15°	20°	30°	40°
1	HP	HUB	8.0	40MHz/60Mbps	2.0	2	14.7	1	0	100% of BEAM	-14.5	-15.2	-9.8	-7.6	-2.3	2.1
2	HP	HUB	8.0	40MHz/60Mbps	0.5	1	14.7	1	0	30% of BEAM	-15.4	-15.8	-15.4	-13.1	-8.3	-3.8
3	HP	HUB	8.0	40MHz/60 Mbps	1.0	1	14.7	1	0	MIAMI	2.6	2.7	-7.7	-8.8	-8.1	-3.7
4	HP	HUB	8.0	40MHz/60Mbps	2.0	2	14.7	1	0	New York	-2.7	-2.7	-6.4	-7.6	-2.3	2.1
5 (33%)	HP	HUB	8.0	40MHz/60Mbps	2.0	2	14.7	1	0	New York	-9.3	-9.7	-7.8	-7.6	-2.3	2.1
6	HP	HUB	8.0	40MHz/60Mbps	4.0	2	14.7	1	0	NY+PHILA +DC	-2.2	-2.2	-3.8	-1.6	3.7	8.1
7 (33%)	HP	HUB	8.0	40MHz/60Mbps	4.0	2	14.7	1	0	NY+PHILA +DC	-5.3	-5.6	-3.8	-1.6	3.7	8.1
8	HP	HUB with scattering	8.0	40MHz/60Mbps	2.0	2	14.7	1	0	100% of beam	-14.5	-15.2	-9.8	-7.6	-2.3	2.1
9	HP	SUB	14.0	1MHz/T1	2.0	2	14.7	15	0	100% beam	-7.1	-7.0	0.5	1.8	3.4	4.6
10(33%)	HP	SUB	14.0	1MHz/T1	2.0	2	14.7	15	0	New York	-6.2	-6.4	2.9	1.8	3.5	4.7
11	HP	SUB	14.0	1MHz/T1	2.0	2	14.7	15	0	New York	0.4	-0.4	4.6	1.7	3.4	4.6

[1]Note that in some cases as described in footnote 2 below, the entire SMA area may not be covered simply because the beam footprint itself is smaller than the SMA area. This is usually true at the higher beam elevations. The footprint areas for the indicated elevations are: 141540km^2(0°); 151300km^2(5°); 39900km^2(15°); 19587km^2(20°); 7212km^2(30°); and 3612km^2(40°). For comparison, the areas of the MSAs are: 19825km^2(New York); 8196km^2(Miami), and 50702km^2 (New York + Philadelphia + Wash D.C. MSAs combined). Also, where the footprint area is larger than the SMA area and the 33% rule is assumed, the area occupied by LMDS cells is considered to be the SMA area + 33% of the area remaining in the footprint

TABLE B7

12	HP	SUB	14.0	1MHz/T1	1.0	1	14.7	15	0	Miami	5.9	6.2	3.7	0.9	-2.3	-1.2

TABLE 38

Radiocommunication
Study Groups
Period 1993 - 1995

Doc. WP 7B/9D/CAN 1
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CANADA

Considerations for Bandsharing Between the Inter-Satellite Service and the Fixed Service Employing Local Multipoint Communications Systems

1.0 INTRODUCTION

This sharing study examines the potential impact of transmitters of Local ~~Microwave~~ Multipoint Communications Systems (LMCS) would have on the receivers of Data Relay Satellites (DRS) in the Inter-Satellite Service (ISS) band at 25.25 to 27.5 GHz (26 GHz). This sharing study also examines the potential impact which interference from the transmitters of low Earth orbit 'User' spacecraft would have on LMCS systems in the 26 GHz band. This band exhibits favourable propagation characteristics which could be used to advantage by a two-way microcell-type communication system such as LMCS.

2.0 PARAMETERS FOR THE ISS AND LMCS RECEIVERS

2.1 Inter-Satellite Service (Return Link) Parameters

Table 1 below has been taken from ITU-R document Doc. 7B/26 (9D/54) which was included in the Chairman's Report from the November 1994 Second Joint Meeting of Ad Hoc Working Parties 7B and 9D. The transmit gain of the antenna in the ISS Return Link has been frequency scaled here to the centre of the 26 GHz band. The noise temperature of the DRS was taken from ITU-R Draft New Rec. [Doc. 7/9]. The side-lobe patterns for the User Satellite and the DRS were taken from ITU-R Doc. 7B/26 (9D/54).

Table 1: Parameters of ISS Return Link

ISS Frequency	Centre Frequency	26.375 GHz
User Satellite	Transmitting Power Antenna Gain	7.3 dBW 49.9 dBi
Data Relay Satellite	Antenna Gain Noise Temperature	58.0 dBi 1200 K

Note: Transmit bandwidth = 4 MHz.

2.2 LMCS Parameters

The transmit and receive parameters for two LMCS systems are given in Tables 2.1 and 2.2. Typical LMCS cell sizes for the LMCS systems by climatic zone are given in Table 2.3. Figures 1 and 2 graphically illustrate cell radii and clear-sky power per 100 km^2 both as a function of rain climatic zone for the LMCS 'A' and LMCS 'B' systems, respectively.

2.2.1 LMCS Antenna Parameters

The LMCS hub and subscriber antenna patterns used in this sharing study were taken from data provided by LMCS equipment manufacturers . LMCS hub stations employ a toroidal transmit antenna pattern which is omni-directional in the horizontal plane but directive in the vertical plane. The vertical plane patterns of the LMCS hub antennas are given in Figures 3 and 4. The hub vertical plane antenna patterns exhibit slightly better discrimination than the patterns contained in Annex 11 of Doc. 7B/26 (9D/54). The subscriber antennas for the LMCS systems employ highly directional patterns with maximum gains ranging from approximately 30 to 35 dB and are shown in Figures 5 and 6.

2.3 Geometrical Considerations

For practical purposes the hub has a negative elevation angle in order to effectively deliver service to as many subscribers as possible in a given service area while minimizing interference to adjacent cells. For example, hub elevation angles of -1.9° and -2.3° for the LMCS 'A' and 'B' systems, are required to ensure maximum coverage within the cells. As a consequence of the hub configuration, a subscriber's elevation angle will always be positive. For both LMCS 'A' and LMCS 'B' which both have typical service areas of roughly 5 km in radius in Rain Climatic Zone M (Rec. ITU-R PN.837), it was assumed that the hub was situated at an average of 60 m above the surrounding area. Assuming a uniform distribution of subscribers around the hub, nearly all (99%) subscribers could 'see' the hub antenna at positive elevation angles less than about 6° (see Figures 7 and 8). Negligible interference from subscriber antennas to DRS can be expected from elevation angles above 6°. In Rain Climatic Zone K, slightly larger cell sizes are feasible and will result in a distribution in which the elevation angle of nearly all subscribers is less than 5°. Thus, in Zone K and in other less severe rain rate zones than Zone M, most potential subscriber interference may occur at lower elevation angles those than in Zone M.

The distribution of subscriber elevation angles for LMCS 'A' and 'B' is illustrated in Figures 7 and 8. Subscribers closer to the hub will receive a proportionately stronger signal than at the outer limit of coverage. The received subscriber powers at the hub, not including differences in hub antenna gain, for LMCS 'A' and 'B' is shown as a function of subscriber elevation angle in Figures 9 and 10.

Table 2.1: LMCS Receiver Parameters

LMCS System	Terminal Type	Grx(max) (dBi)			Modulation of Traffic 1	2	3	4
'A'	Subscriber	31.0			TV/FM			
			Receive Bandwidth	(MHz)	18.0			
			C/(N+I)req (clear-sky)	(dB)	26.0			
			C/(N+I)req (rain)	(dB)	13.0			
	Hub	21.0			16 kb/s	64 kb/s	384 kb/s	1544kb/s
			Receive Bandwidth	(MHz)	0.010	0.040	0.240	1.000
			C/(N+I)req (clear-sky)	(dB)	16.0	16.0	16.0	16.0
			C/(N+I)req (rain)	(dB)	13.0	13.0	13.0	13.0
'B'	Subscriber	35.0			Digital 1	Digital 2	TV/FM	
			Receive Bandwidth	(MHz)	52.0	5.2	17.0	
			C/(N+I)req	(dB)	13.0	13.0	18.0	
	Hub	15.0			Digital 1	Digital 2		
			Receive Bandwidth	(MHz)	52.0	5.2		
			C/(N+I)req	(dB)	13.0	13.0		

Table 2.2 LMCS Transmitter Parameters

LMCS System	Terminal Type	Gtx(max) (dBi)			Modulation of Traffic 1	2	3	4
'A'	Hub	12.0			TV/FM			
			Transmit Bandwidth	(MHz)	18.0			
			TX Power	(dBW)	-6.0			
	Subscriber	31.0			16 kb/s	64 kb/s	384 kb/s	1544kb/s
			Transmit Bandwidth	(MHz)	0.010	0.040	0.240	1.000
			TX Power	(dBW)	-41.0	-34.8	-27.2	-21.0
'B'	Hub	15.0			Digital 1	Digital 2	TV/FM	
			Transmit Bandwidth	(MHz)	52.0	5.2	17.0	
			TX Power (clear-sky)	(dBW)	-12.0	-22.0	-12.0	
			TX Power (rain)	(dBW)	0.0	-10.0	0.0	
	Subscriber	35.0			Digital 1	Digital 2	Digital 4	
			Transmit Bandwidth	(MHz)	52.0	5.2	5.2	
			TX Power (clear-sky)	(dBW)	-12.0	-22.0	-32.0	
			TX Power (rain)	(dBW)	0.0	-10.0	-20.0	

Notes for Table 2.1 and 2.2

Note 1) Clear-sky C/(N+I) for LMCS 'A' is based upon ideal cell size at 29 GHz in Rec. ITU-R PN.837 Rain Zone M.

Note 2) Clear-sky TX Power for LMCS 'B' is based upon ideal cell size at 29 GHz in Rec. ITU-R PN.837 Rain Zone M.

Table 2.3: Average LMCS Cell Size and Required Clear-Sky Transmit Power as Function of Rec. ITU-R PN.837 Rain Climatic Zone

Frequency	28.375 GHz	
Water Vapour Density	7.5 (g/m^3)	
Clear-Sky Attenuation	0.12 (dB/km)	(Rec. ITU-R PN.676-2 and Rec. ITU-R PN.836)

LMCS Parameter	LMCS 'A'	LMCS 'B'		
Availability	99.9	99.9	%	
Path Att'n: FSL + Atmos + Rain	148.5	150.8	dBW	
Maximum Ptx (Hub) (TV/FM)	-17.00	-12.30	dBW/MHz	(With Maximum Automatic Power Control (APC) where applicable)
Maximum Ptx (Hub) (Digital)	N/A	-17.10	dBW/MHz	(With Maximum Automatic Power Control (APC))
Maximum APC	0.0	20.0	dB	
Gtx (Hub)	12.0	12.0	dBi	(Net after pointing error tolerance)
Grx (Subscriber)	31.0	34.0	dBi	
Subscriber Thermal Noise	-138.0	-138.0	dBW/MHz	
Minimum C/N (with Rain)	14.9	18.9	dB	
Minimum C/N (no rain)	various	21.9	dB	(Rec. ITU-R PN.837 Rain Climatic Zone M)

Rain Zone	B	C	D	E	F	G	H	J	K	L	M	N
R_0.01% (mm/h)	12	15	19	22	28	30	32	35	42	60	63	95
R_0.1% (mm/h)	3	5	8	6	8	12	10	20	12	15	22	35

Average Cell Sizes (Using an Average of Horizontal and Vertical Polarization Parameters)

LMCS 'A'	B	C	D	E	F	G	H	J	K	L	M	N
Avg. Distance (km)	11.06	10.11	9.12	8.52	7.58	7.30	7.08	6.74	6.11	5.03	4.90	3.98
Avg. Rain Fade A(0.1%) (dB)	5.42	6.30	7.32	7.98	9.13	9.47	9.78	10.25	11.17	12.98	13.22	15.11
Avg. C/N (No Rain) (dB)	20.3	21.2	22.2	22.9	24.0	24.4	24.7	25.1	28.1	27.9	28.1	30.0
LMCS 'B'	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**	**N**
Avg. Distance (km)	12.90	11.81	10.58	9.84	8.67	8.36	8.07	7.68	6.93	5.67	5.52	4.49
Avg. Rain Fade A(0.1%) (dB)	6.08	7.06	8.15	8.87	10.11	10.47	10.81	11.29	12.27	14.16	14.41	16.34
Aggregate APC -> DRS(dB) (Note 1)	0.31	0.40	0.52	0.59	0.71	0.75	0.78	0.83	0.93	1.12	1.14	1.33

Required Transmit Powers in Clear-Sky Conditions (Note 2)

LMCS 'A': Ptx (dBW/MHz)	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00	-17.00
LMCS 'B': TV/FM: Ptx (dBW/MHz)	-15.38	-16.36	-17.46	-18.17	-19.41	-19.77	-20.11	-20.59	-21.57	-23.46	-23.71	-25.64
LMCS 'B': Digital: Ptx (dBW/MHz)	-20.24	-21.21	-22.31	-23.03	-24.27	-24.63	-24.97	-25.46	-26.43	-28.32	-28.57	-30.50

Note 1): Assumes 10% of all cells are transmitting with the maximum APC - 3 dB (0.1% Rain Fade Compensation).
No TPC is implemented for fades less than the 3 dB threshold.

Note 2): All stated powers are average over the transmission bandwidth.
A peak to average factor from Table 3 is applied when calculating interference into the DRS.

2.4 LMCS Rain fade Compensation

Automatic Power Control (or APC) is a technique that may be useful to LMCS to compensate for detected rain fade. In this study, APC is employed by LMCS 'B'. LMCS 'B' has a minimum C/N of 18.9 dB in the TV/FM case or 14.0 dB in the digital case in the hub to subscriber direction. Table 2.3 derives the cell sizes based upon maintaining the above minimum C/N.

Low elevation angle interference into the DRS is worse than high elevation angle interference due to LMCS antenna patterns and geometries. However, the interfering signal is passing through more troposphere which more than compensates for any lesser correlation between APC and rain attenuation on the interference slant paths, below about 15°, to the DRS. Under rain conditions, it was assumed that in both the space-to-Earth and the Earth-to-space direction the interference from the 'User' satellite on the downlink and from the aggregate interference of the LMCS hub stations (and subscriber terminals) on the uplink were attenuated by a 10 % rain fade derived from Rec. ITU-R PN.618-2. It has been assumed that it is statistically unlikely that, in the total area of the 3 dB DRS receive antenna beamwidth, more than 10% of all visible cells will be experiencing a maximum 0.1% rain fade at any instant. Thus, the resultant aggregate uplink interference is composed of a level of APC corresponding to a 0.1% rain fade from 10% of all visible LMCS cells and no APC from the remaining 90% of all visible LMCS cells. In all cases, assumed fading conditions on the interference path resulted in lower levels of aggregate interference into the DRS for elevation angles below about 15° than under clear-sky conditions. For elevation angles above about 15°, aggregate interference into the DRS was slightly greater than under clear-sky conditions; however, margins were much greater. Rain attenuation is further discussed in section 3.2.

2.5 LMCS Power Spectral Density

In this study, ratios of power in the worst 1 MHz to the average power over the worst 1 MHz were added to the average power over the transmission bandwidth according to the type of modulation employed. These approximate peak power spectral density ratios are given in Table 3 below for two types of modulation.

Table 3: Peak Power Spectral Density Ratios

Modulation of LMCS Transmission	Peak (Worst MHz)/Average Power Ratio (dB)
Digital (4 phase)	3.0
TV/FM	10.0

3.0 OTHER CONSIDERATIONS IN THE DETERMINATION OF THE LEVEL OF INTERFERENCE BETWEEN LMCS SYSTEMS AND THE ISS

3.1 Clear-Sky Atmospheric Attenuation on Interference Slant Paths

As the 26 GHz band exhibits significant fading characteristics due to atmospheric gases for slant paths of low elevation angles, the effect of atmospheric attenuation cannot be ignored. The atmospheric attenuation prediction model used in this study was that from Rec. ITU-R PN.676-1. In addition to frequency, the minimum attenuation calculated by the model depends upon: i) height above mean sea level (amsl) of the point on or above the surface of the earth, ii) Rec. ITU-R IS.847 Radioclimatic Zone (A1, A2, B or C) and iii) the elevation angle of the slant path to the satellite. A ground elevation of 360 m (amsl) at the hub antenna was assumed such that less atmospheric attenuation would be calculated than would be experienced for most typical situations. Also, using the more general value of water vapour density from radioclimatic zones in Rec. ITU-R IS.847 instead of a more specific value from Rec. ITU-R PN.836 will lead to a lower estimate of attenuation due to atmospheric gases. The Rec. ITU-R P.676-1 clear-sky attenuation due to atmospheric gases is shown in Figure 11. The Rec. ITU-R PN.676-1 attenuation due atmospheric gases in the presence of rain, which is slightly higher due to a higher 'water vapour equivalent height', is also shown in Figure 11.

3.2 Rain Attenuation on Interference Slant Paths

The effect of rain attenuation in a temperate climatic zone has been shown to illustrate its role in the mitigation of interference. Figure 12 shows the expected rain attenuations for Rec. ITU-R PN.837 Rain Climatic Zone M for a range of elevation angles using the Rec. ITU-R P.618-2 model. It should be noted that the ITU-R rain attenuation model does not apply at percentages of time above 1%. The 10 % (A_{10}) rain fade values were estimated by calculating the 0.1% and the 1% attenuations ($A_{0.1}$ and $A_{1.0}$) and calculating the fourth order coefficients to a curve which passes through the two points and through an attenuation of 0 dB exceeded for 100%. A family of curves, for values of p (%), illustrating the elevation angle dependency of the expected rain attenuation on the interference path is given in Figure 13.

LMCS systems generally radiate power horizontally. Also, LMCS systems are designed to have typical design availabilities of 99.9 %. Thus, increased attenuation due to rain and atmospheric gases on interference slant paths between the LMCS and the DRS in combination with the levels of APC required to achieve an availability of 99.9% in a typical cell size, results in the interference calculated under clear-sky conditions as being the worst case. This cancelling effect will be more pronounced on interference paths where the LMCS antenna has a better vertical plane discrimination. In both the Earth-to-space and the space-to-Earth directions, the net effect of rain is one of interference reduction for low elevation angles. The overall effect of rain attenuation on LMCS hub stations and subscriber terminals is a net reduction of interference along low elevation angle slant paths having elevation angles less than about 10° to 25° and a slight reduction in system margin on slant paths of greater elevation. The overall effect of rain attenuation on a receiving DRS is a net reduction of interference along low angle slant paths having elevation angles less than about 10° to 15° and a slight reduction in system margin on slant paths of greater elevation.

3.3 Linear to Circular Polarization Discrimination

The ISS and LMCS employ different polarization schemes. The ISS employs circular polarization for operational reasons. LMCS, however, employs rectangular/linear polarization for purposes of facilitating intra-service sharing between nearby cells. In the instance where the main beam of an interfering transmission is in-line with the main beam of a receiver, 3 dB of discrimination can be expected; otherwise no discrimination is assumed.

In the space-to-Earth direction, the highly directive beam on the User satellite should not illuminate any portion of the surface of the earth with its main beam and thus no circular-to-linear polarization discrimination can be expected when calculating interference into the LMCS receivers.

In the Earth-to-space direction, when the User satellite is between the DRS and LMCS transmitters whose main beams are directed towards the DRS and are also in the main beam of the tracking antenna on the DRS, 3 dB of polarization discrimination toward the DRS receiver can be assumed. As a result, 3 dB of polarization discrimination can be expected when the elevation angle to the DRS from an LMCS hub is below 7 or 8° or when the elevation angle to the DRS from an LMCS subscriber is within approximately 3 to 5° of the boresight elevation of the subscriber antenna.

In heavily rain faded conditions, the 3 dB linear-to-circular polarization discrimination which is achieved under clear-sky conditions, will not be present due to the depolarizing effect of rain at these frequencies. In the calculation of aggregate uplink interference, however, loss of linear-to-circular polarization discrimination was considered to be negligible as it assumed that it would be statistically unlikely for more than 10% of all cells to be experiencing a 0.1% rain fade ($A_{0.1}$) at any instant. Thus, under rain faded conditions, 3 dB of discrimination was assumed on the aggregate interference level into the DRS when the transmitting LMCS main beam was in the main beam of the DRS receiving antenna.

3.4 Atmospheric Refraction and Beam Spreading Effects at Low Elevation Angles

Signal loss resulting from spreading of the beam on the LMCS antenna caused by a variation of atmospheric refraction has been considered for elevation angles below 5°. The attenuation on the interference slant path due to beam spreading effects was calculated using Rec. ITU-R PN.834. The apparent elevation angle, due to tropospheric refraction on the interference slant path was used in the calculation of beam spreading, angular discrimination calculations for LMCS antennas and in polarization discrimination calculations.

4.0 RESULTS

The two main interference mechanisms between LMCS and the ISS are: i) ISS Return Link into LMCS receivers and ii) LMCS transmitters into DRS receivers.

4.1 Inter-Satellite Service (Return) Link into LMCS Receivers

For the LMCS systems, interference due to ISS Return Links from User satellites caused no significant degradation to designed service margins. There are two different interference modes in the case of space-to-Earth interference. The first mode of interference occurs when the Return Link from a User satellite causes interference into the LMCS Hub receiver. The second mode of interference occurs when the Return Link from a LEO space-craft causes interference into the LMCS subscriber receiver.

The second of these two interference modes is obviously the worst case since the LMCS subscriber antenna gain toward the satellite for elevation angles less than 10° tends to be much greater than in the case of the LMCS hub. The two main reasons for this are that a typical subscriber antenna has a maximum gain of approximately 20 dB greater than that of the hub and the subscriber has a predominantly positive elevation angle.

Using the Return Link satellite parameters from Table 1, it was determined that a minimum off-pointing angle between the User Satellite main beam and the limb-of-the-Earth must be maintained in order for the User Satellite to meet the RR2578 pfd limits of -115 dB(W/m²/MHz) for angles of arrival below 5° and -105 dB(W/m²/MHz) for angles of arrival above 25°. This minimum off-pointing angle was calculated to be 3°. Interference into both the LMCS hub and LMCS subscriber receivers were calculated assuming the surface of the Earth was illuminated by a pfd equivalent to the RR2578 limit as this was the worst case. The worst case pfd from the User satellite assuming the 3° off-pointing restriction is shown in Figure 14.

4.1.1 Inter-Satellite Service (Return Link) into LMCS Hub Receivers

For all LMCS systems, interference due to ISS Return Links from LEO satellites caused no significant degradation to the FS system margins. Results of interference calculations into LMCS hub receivers are presented in Table 4.

4.1.2 Inter-Satellite Service (Return Link) into LMCS Subscriber Receivers

Positive interference margins are always maintained in the presence of interference from ISS Return Links. The results of interference calculations indicated that the degradation of system margin would be more severe for lower subscriber elevation angles and less severe for higher subscriber elevation angles. Both TV/FM and digital subscriber receivers, although experiencing some reduction in margin, did not experience a negative interference margin over any angular range. Results of interference calculations into LMCS subscriber terminal receivers are presented in Table 4.