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1.0 Introduction

This report documents the work of Working Group 1 of the LMDS/FSS 28 GHz Band Negotiated Rulemaking Committee. (LMDS = Local Multipoint Distribution Service; FSS = Fixed Satellite Service.) The NRMC was tasked to "gather and discuss information necessary to form recommendations to the FCC for technical regulations that should be adopted for the Local Multipoint Distribution Service and/or the Fixed Satellite Service so as to maximize the co-frequency sharing of the spectrum among these services." (Attachment A, Charter of the NRMC, Document NRMC-1.)

1.1 Work Plan

Under the direction of the NRMC, Working Group 1 was formed to examine cases 1, 3, 4, 5, 7 and 8 of the NRMC Work Plan (Attachments B & C, Documents NRMC-8 (Rev. 1) and NRMC-25, items 2 and 3). These cases deal with the sharing possibilities and the interference analyses between LMDS systems and satellite systems providing service links in the 27.5 - 29.5 GHz frequency band. The Working Group developed its work program as described in Attachment D, Doc. NRMC-27. Additionally, cases dealing with power control beacons were examined.

The activities/milestones developed by Working Group 1 to guide its work are given below.

Activities/Milestones for the Working Group 1

Set Work Plan
Organize Group
System Parameters Definition
Review Systems Parameters
Develop Analysis Methodology & Equations
Analyses
Review Analysis
Recommendation & Rules Formulation
Progress Reports
Final Report

1.2 Working Group Statistics

Working Group 1 organized itself as shown within the overall NRMC structure (NRMC 35 (Rev. 2)).

WG1 was organized into two subgroups:

WG1A	Cases a and b of the WG1 work program, where there is potential for FSS transmitters to cause interference to LMDS receivers
WG1B	Cases c and d of the WG1 work program, where there is potential for LMDS transmitters to cause interference to FSS receivers.

The business of subgroups was conducted by focusing the agenda of each specific WG1 meeting on either WG1A of WG1B activities.

Activities of the Working Group were supported (as shown in Figure 1.2-1) by joint meetings of Working Groups 1 and 2, by a Joint Technical Sub-Group (JTSG), by two Modelling and Analysis Sub-Groups (one each for 1A and 1B), by an Ad Hoc Rules and Regulations Drafting Group, by a Mitigation Opportunities Group, and by a Systems Parameters Database.

1.3 Assignment of Tasks

1.3.1 Working Group 1A Tasks

Working Group 1A was responsible for carrying out modeling, analyses, evaluations, and development of conclusions, rules, and recommendations in the following cases:

- GEO FSS earth stations causing potential interference on an individual and aggregate basis into LMDS subscriber receivers and hub (upstream) receivers.

- Non-GEO FSS earth stations causing potential interference on an individual and aggregate basis into LMDS subscriber receivers and hub receivers.

1.3.2 Working Group 1B Tasks

Working Group 1B was responsible for carrying out modeling, analyses, evaluations and development of conclusions, rules and recommendations in the following cases:

- LMDS transmitters which may be located, for example, at hub stations and subscriber terminals, causing potential interference, on an individual station basis or as an aggregate of all visible transmitters, to FSS geostationary-earth orbit satellite receivers.

- LMDS transmitters which may be located, for example, at hub stations and subscriber terminals, causing potential interference on an individual station basis or as an aggregate of all visible transmitters, to FSS non-geostationary earth orbit satellite receivers.

- FSS satellite downlink beacon (see RR 882A, WARC-92), intended for up link power control and operating in the band 27.500 - 27.501 GHz, causing potential interference to LMDS hub stations and subscriber terminals.

- LMDS hub stations and subscriber terminals causing potential interference, in an individual station basis or as an aggregate of all visible subscriber terminals and hub stations, to FSS satellite downlink beacon (see RR 882A, WARC-92) Earth Station Receivers.

1.4 Working Group Meetings and Participation

The participants in Working Group 1 are listed in Attachment E. Working Group 1A held 18 meetings; Working Group B, 20.

2.0 Descriptions of System Characteristics

2.1 General Descriptions of LMDS Systems

The proposed Local Multipoint Distribution Service (LMDS) is a two-way point-to-multipoint and multipoint-to-point service operating in the 27.5-29.5 GHz millimeter wave frequency range. As proposed, two licenses would be granted in each Basic Trading Area (BTA) as defined by Rand McNally, one at 27.5-28.5 GHz band and one at 28.5-29.5 GHz. Path lengths are relatively short at this frequency range, but each licensee would employ frequency reuse techniques (e.g., antenna directionality, polarization isolation, frequency offset) so that the same 1000 MHz of spectrum would be used to provide service throughout the licensee's service area.

The Negotiated Rulemaking Committee and its Working Groups considered LMDS system designs provided by three entities: Suite 12/CellularVision; VideoPhone/Endgate; and Texas Instruments. These three system designs are similar in that they all employ a cellular design, with frequencies being reused at each cell. However, each system design is unique in some aspect. The three designs are described more fully below. Section 6 provides all the detailed parameters used in the analysis.[1]

Suite 12/CellularVision

The Suite 12/CellularVision system, which is currently operational, is intended primarily to provide a video distribution service, with two-way voice and data capability also available. It consists of 49 channels of frequency modulated video. Two-way voice and data signals are carried in the interstitial frequency spaces between video channels. A typical cell size is 4.8 km radius. Each cell employs an omnidirectional or wide-beam antenna. Each subscriber location employs a highly directional antenna. Isolation between hub transmissions in adjacent cells is achieved by cross-polarization isolation, frequency interleaving and the directionality of the subscriber antenna. Two-way voice, video and data transmissions are supported by FM and by data rates of 16 kbit/sec to 1.544 Mbit/sec. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	FM video	Digital
Output Power	-5 dBW per channel	-41 to -21 dBW
Antenna Gain	12 dBi	31 dBi
Bandwidth	18 MHz	0.01 to 1 MHz
Cell Radius	4.8 km	4.8 km

VideoPhone/Endgate

The proposed VideoPhone/Endgate architecture incorporates optional AM, FM and

digital modulation configurations to provide a variety of one-way and two-way voice, data and video services. Hub density, intended cell coverage radius, the degree of cell sectorization, EIRP levels, and other parameters in a typical VideoPhone/Endgate deployment will vary according to service demand and interference environment conditions. VideoPhone/Endgate may also employ hub diversity in some deployments to allow users to orient antennas toward multiple hub locations, as well as dynamic channel assignment and other operational capabilities. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	Digital	Digital
Output Power per Channel	-70 to -4.8 dBW	-78 to 0 dBW
Antenna Gain	29.7 dBi	38 dBi
Bandwidth	6 to 20 MHz	1.5 to 100 MHz
Cell Radius	0.8 km	0.8 km

Texas Instruments

The Texas Instruments system will consist of several digital alternatives as well as FM video and AM video. A typical cell size will be 5.0 km radius (1.0 km for AM video), but cells overlap so a typical hub-to-hub distance would be 5.0 km. Each cell will employ an omnidirectional or wide-beam antenna. Each subscriber location will employ a highly directional antenna. Isolation between hub transmissions in adjacent cells will be achieved by the directionality of the antennas and cross-polarization isolation. Typical parameters are as follows:

Parameter	Hub Station	Subscriber Station
Modulation	Digital, FM video	Digital
Output Power per Channel*	0 to -22 dBW	0 to -32 dBW
Antenna Gain	15 dBi	35 dBi
Bandwidth	5.2 to 52 MHz	5.2 to 52 MHz
Cell Radius	5.0 km	5.0 km

*Maximum power stated allows for rain attenuation; minimum power allows for clear air.

[1] GHz Equipment Company, Inc.'s (GEC) proposed system, while containing some differences from the Suite 12 system, exhibits esentially identical parameters. It was, therefore, GEC's decision not to submit redundant specifications. Conclusions attributed to Suite 12's system may be applied to GEC's system, as well.

2.2 General Description of FSS Service Links

This section describes the general characteristics of FSS systems that will use the 27.5 - 29.5 GHz band for service uplinks. Information was provided by the system proponents.

2.2.1 The Teledesic Network

The proposed Teledesic Network uses a constellation of 840 operational interlinked low-Earth orbit satellites and up to four operational spares per orbital plane to provide national and global access to a broad range of voice, data and video communication capabilities. The system is designed to access terminals located anywhere in the country. Typical satellite coverage footprints over the United States are shown in Figure 2.2.1-1. As the satellites in the Teledesic Network design move in their orbits, the satellite coverage footprints move, and different satellites become visible from the ground. The Teledesic satellite constellation is designed to ensure that there is always at least one satellite visible above a 40° elevation angle over the entire coverage area. The proposed satellite constellation is organized into 21 circular orbit planes that are staggered in altitude between 695 and 705 km. Each plane contains a minimum of 40 operational satellites plus up to four on-orbit spares spaced evenly around the orbit.

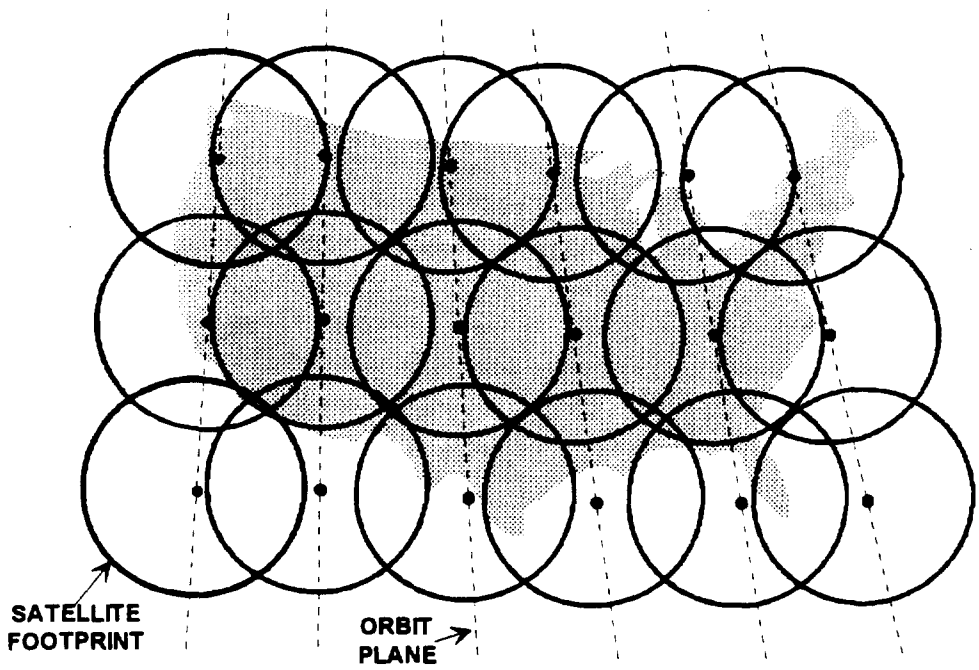

Figure 2.2.1-1 Teledesic's Footprint Coverage Over The Contiguous U.S.

The proposed system uses Ka band frequencies authorized for fixed satellite service (FSS) use for both uplinks and downlinks. The uplinks are proposed in the bands 27.6 - 28.4 GHz and 28.6 - 29.0 GHz. The Teledesic Network design accommodates a wide variety of terminals and data rates. Standard Terminals will include both fixed-site and transportable configurations that operate at multiples of the 16 kbps basic channel rate up to 2.048 Mbps (the equivalent of 128 basic channels). The Network also supports a smaller number of fixed-site GigaLink Terminals that operate at the OC-3 rate ("155.52 Mbps") and multiples of this rate up to OC-24 ("1.24416 Gbps"). A satellite can support up to sixteen GigaLink terminals within its service area.

The Teledesic system maps the Earth's surface into a fixed grid of approximately 20,000 "supercells," each consisting of nine cells approximately 53 km square. The proposed Teledesic Network uses an earth-fixed cell design to minimize communications hand-offs across cell boundaries. The network uses a combination of multiple access methods to ensure efficient use of the spectrum. Each cell within a supercell is assigned to one of nine equal time slots. All communication takes place between the satellite and the terminals in that cell during its assigned time slot. Within each cell's time slot, the full frequency allocation is available to support communication channels. The cells are scanned in a regular cycle by the satellite's transmit and receive beams, resulting in time division multiple access ("TDMA") among the cells in a supercell. On board, fast packet switching and intersatellite routing of signals is used to interconnect cells within the United States (or anywhere in the world). The concept of fixed grid cells is illustrated in Figure 2.2.1-2.

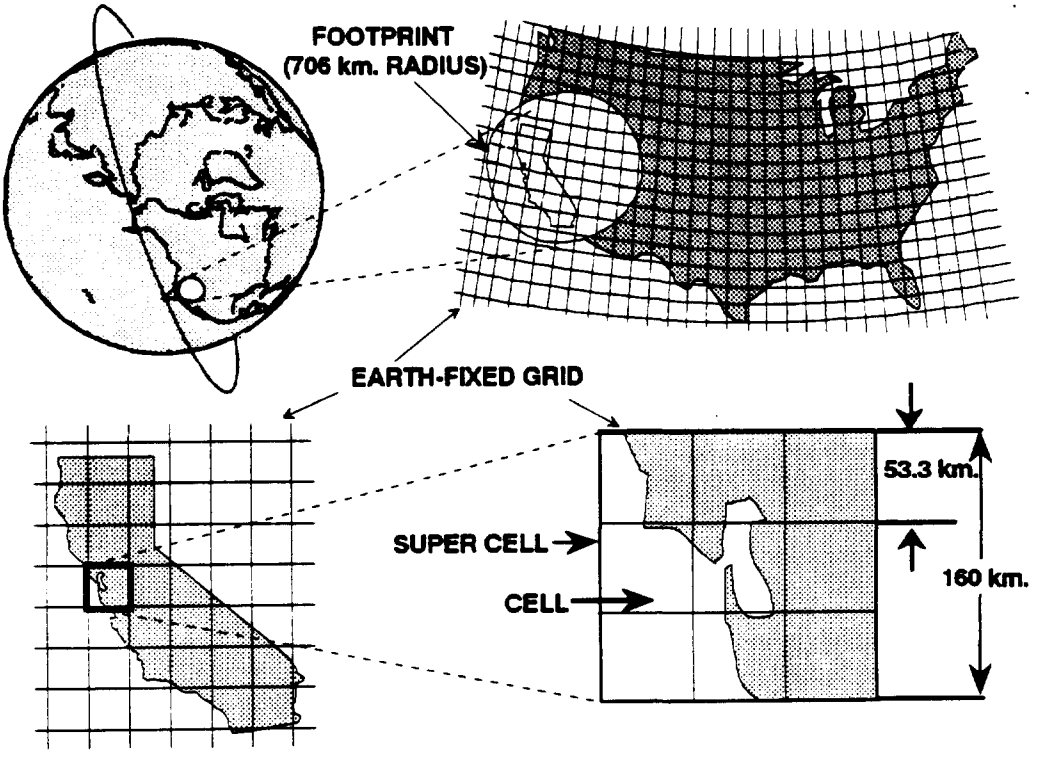

Figure 2.2.1-2 Teledesic's Earth-Fixed Cells

The Teledesic Network will provide a quality of service comparable to today's modern terrestrial communication systems, including fiber-like delays, bit error rates less than 10^{-9}, and a link availability of 99.9% over most of the United States and similar climatological areas. Power control on the uplink transmitters will be used to achieve the high availability.

Spacecraft experiments and associated user earth terminals are planned for 1996 through 1999. Operational system installation would occur during 2000 and 2001, with the worldwide Teledesic Network fully operational in 2001. Some initiation of service would be possible during the development phase.

Detailed technical characteristics of the Teledesic Network are given in Attachment F. These parameters were used in analyses to evaluate co-frequency sharing.

2.2.2 SPACEWAY Network

The proposed SPACEWAY system will use geostationary satellites to provide worldwide, cost-effective, ubiquitous, two-way voice, medium- and high-speed data, image, video and videotelephony communications services to both consumer and commercial users via inexpensive ultra small aperture terminals. Please refer to NRMC document 40.1 for a detailed SPACEWAY system summary.

SPACEWAY will be implemented in a phased, regional approach commencing with the introduction of the first two satellites for service within the United States and will then be expanded to a network of four interconnected regional satellite systems servicing North America, Asia Pacific, Central/South America, and Europe/Africa. Figures 2.2.2-1 and 2.2.2-2 depict the phased implementation of the SPACEWAY network. The first satellites in the SPACEWAY network will be operational in 1998 and will provide full coverage to all fifty states of the United States. Phase One, completed by 2000, will provide a global initial operating capability based on nine satellites. Phase Two will provide final operating capability through the addition of eighth satellites by 2003.

SPACEWAY will be an all-digital system using state-of-the-art advances in satellite technology to provide full duplex interactive circuits throughout the world and features on-board signal processing, on-board switching, small, easily installed ground terminals, and digital transmissions at a variety of bit rates. The use of an on-board switch/processor will provide individual end users with "on demand" access to the space segment, and will allow two-way transmissions within and between subscriber terminals in the spot beams, as well as interconnection with other satellites in the network.

A key component of the system architecture is the Ka-band spot beam network. This technology will allow the use of extremely small end user terminals (approximately 66 cm) and provide a high degree of spectrum efficiency. Each of the 24 geographically separate spot beams will use two 125 Mhz subbands on opposite circular polarizations. Narrow spot beams (about 1 degree) with a footprint approximately 650 km. in diameter will cover most of the populated world land mass. In certain regions of low population density, wide spot beams (3 degrees) will be used to cover areas about 1950 km. in diameter.

The system allows symmetric and asymmetric data communications at transmission rates from 16 kbps at 1.544 Mbps, depending upon end user requirements and terminal size. At the end of Phase 1, the 9-satellite system will provide over 100,000 simultaneous simplex 384 kbps circuits or the equivalent of over 2 million simultaneous telephone calls. At the end of Phase 2, the 17-satellite system will provide twice these capacities.

Technical characteristics of the SPACEWAY network are summarized in Attachment G.

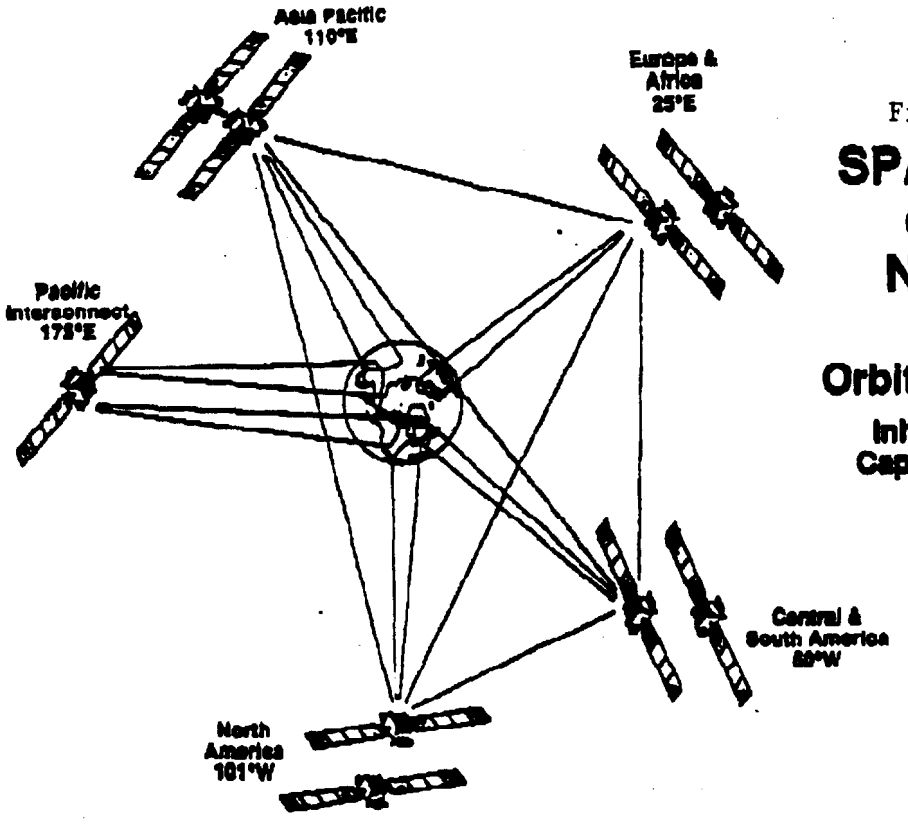

Figure 2.2.2.-1

SPACEWAY™ Global Network

Phase 1

Orbital Locations

Initial Operating Capability by 2000

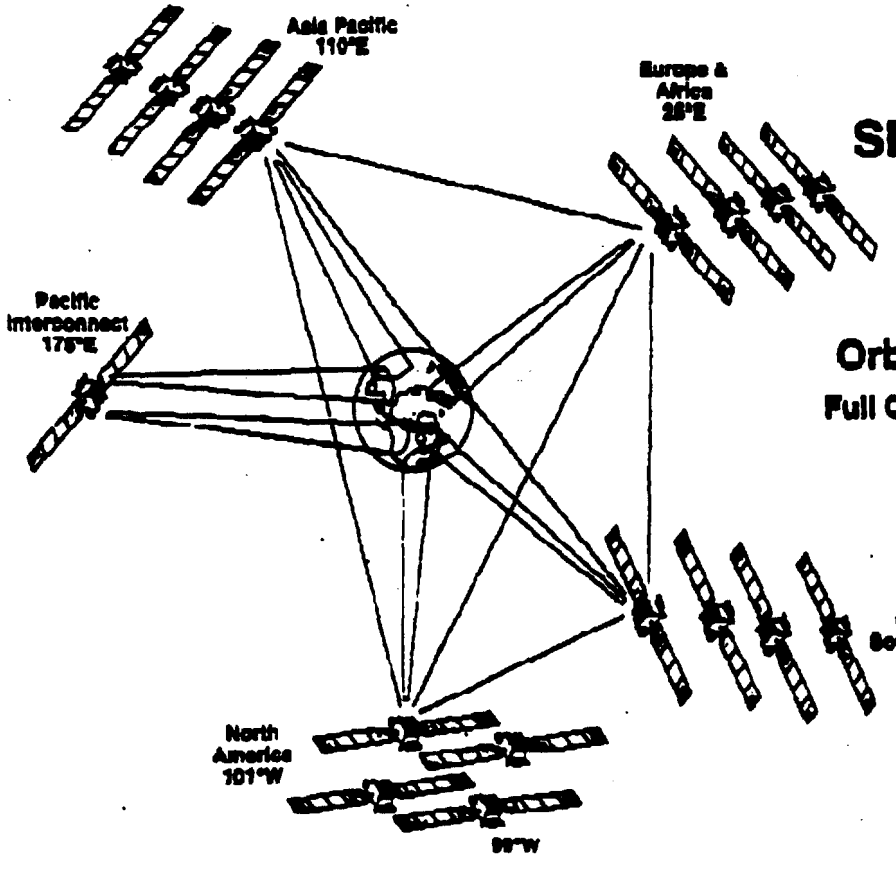

Figure 2.2.2.-2

SPACEWAY™ Global Network

Phase 2

Orbital Locations

Full Operating Capability by 2003

2.2.3. ACTS-Like FSS Systems

The Advanced Communications Technology Satellite (ACTS) is the satellite portion of an experimental system that NASA launched in September 1993 to demonstrate advanced technologies to open up the FSS 20 GHz (downlink) and 30 GHz (uplink) bands.

The ACTS spacecraft provides 6 uplink/downlink spot beams:

3 fixed 0.3° beams;

2 hopping 0.3° beams with 6 to 7 discrete locations or anywhere within designated areas;

1 mechanically steerable 0.9° beam with full visible Earth coverage.

Any 3 uplink beams can be connected to any 3 downlink beams.

On-board Processing:

Microwave switched mode- "bent pipe" operation with 900 MHz wide transponder. Any 3 uplink antenna beams may be connected to any 3 downlink beams with msec. switching time.

Baseband processor mode - On-board processor - data is demodulated and remodulated on-board - allows traffic bursts on any 2 uplink beams to individually routed to any 2 downlink beams. TDMA at 27.5 or 110 Msps (uplink), 110 Msps (downlink) using SMSK modulation.

Power Control Beacon - Unmodulated downlink signal at 27.505 GHz from a CONUS coverage beam at a PFD of -142 dB(W/sq. meter) to allow Earth stations to determine uplink band rain attenuation.

Acts experiments will validate multibeam antenna pattern forming, beam switching and settling times for beam forming networks. Ground system technology experiments will evaluate advanced modulation techniques, Ka-band hardware, small aperture and phased-array vehicle and aircraft antennas, and network control functions for satellite-beam-switched operation with the on-board baseband processor. Propagation studies including antenna beam separation effects, cross polarization in different weather conditions, delay spread, and coherent bandwidth will be conducted. Enhancement of link availability through rain compensation techniques such as; dynamic forward error correction (FEC) and outer level coding; dynamic Earth-to-space power control; dynamic transmission of real-time fade compensation commands; and diversity operation will be conducted.

Application experiments will evaluate a wide range of advanced data, voice, ISDN, video applications.

It was noted that the aggregate interference power received from terrestrial transmitters distributed over a large geographical area is proportional to the area of the beam intersection with the Earth and the receiving antenna gain. For spot beam, as antenna gain increases the beam area decreases by the same ratio. Thus, as determined by number of terrestrial transmitting hubs and/or population density the aggregate interference from an area distribution is approximately independent of spacecraft antenna gain.

The 0.9 degree steerable and the 0.3 degree fixed beam types are the most sensitive. Accordingly, the steerable beam was chosen as the representative case to be used for sharing computations.

The representative ACTS system characteristics to be used for sharing computations are listed in the next section. Transmission power levels, acceptable interference limits, and transmitting earth station antenna sidelobe masks are listed for three representative earth station types.

If interference to LMDS is considered on a per Hz basis, the ACTS USAT-X is the limiting case -- exibiting the highest EIRP power density and least off-axis antenna discrimination (Appendix 29, diameter to wavelength ratio <100). Complete ACTS system characteristics are listed in Attachment H.

2.3 LMDS & FSS System Characteristics Unique to WG1

A central data base of system characterictics unique to WG1 sharing computations was established and updated as needed to make sure that all parties were using common values that had been agreed upon by all proponents as representative of their respective systems.

The system parameters are listed in Table 2.3.1 for each of the LMDS and FSS proponents and have been arranged in the form of link budgets. The calculated Pro/No is equivalent to a C/N value in the signal bandwidth and served the useful purpose of making typographical errors in parameters immediately obvious.

Proponents specified allowed interference level in terms of C/(N+ I) for LMDS and interference power density (Io interference limit) for FSS systems. Appropriate antenna sidelobe masks are specified as a numerical description for each proponent.

The Video/Phone listing notes "2 x cell radius, km" reflecting the fact that power levels are sized to maintain performance margins for a distance of twice the radius of one cell.

Table 2.3.1 - Signal Parameters WG1/52 (Rev 5) 9/20/94

	A	B	C	D	E	F	G	H	I
1									
2	Suite 12	Hub TX	Sub TX	Sub TX	Sub TX	Sub TX			
3	Modulation	TV/FM	16 kbps	64 kbps	384 kbps	1.544 mpbs			
4	Pt, dB(W)	-5.0	-41.0	-34.9	-27.2	-21.0			
5	Gt max, dB(i)	12	31	31	31	31			
6	EIRP, dB(W)	7	-10.0	-3.9	3.8	10.0			
7	BW, MHz	18	0.01	0.04	0.24	1			
8	EIRPo, dB(W/Hz)	-65.6	-50.0	-50.0	-50.0	-50.0			
9	-TX point loss, dB	0.0	0.0	0.0	0.0	0.0			
10	Freq, MHz	29,400	29,400	29,400	29,400	29,400			
11	Cell radius, km	4.8	4.8	4.8	4.8	4.8			
12	-Lbf, dB	-135.5	-135.5	-135.5	-135.5	-135.5			
13	-Rain Loss, dB	-13.0	-13.0	-13.0	-13.0	-13.0			
14	-RX point loss, dB	0.0	0.0	0.0	0.0	0.0			
15	Gr max, dB(i)	31.0	21.0	21.0	21.0	21.0			
16	Pro(rain), dB(W/Hz)	-183.0	-177.5	-177.5	-177.5	-177.5			
17	Tr eff(6 dB nf), K	1160	1160	1160	1160	1160			
18	No, dB(W/Hz)	-198.0	-198.0	-198.0	-198.0	-198.0			
19	Pro/No (Rain), dB	14.9	20.5	20.5	20.5	20.5			
20	1 MHz bw Peaking, dB	8.9	0.0	0.0	0.0	3.0			
21	Interleave factor, dB	-3.0	-3.0	-3.0	-3.0	-3.0			
22	C/(N+I) req, dB	26	16	16	16	16	For Clear Air Conditions		
23	C/(N+I) req, dB	13	13	13	13	13	Under Rain Conditions		
24	Note:	HUB G(elev) - Gmax, dB				SUB G(Ø) - Gmax			
25	Hub RX 8 sectors	if elev< 10 then -3(elev/3.27)^2				if Ø<4.9 then -3(Ø/2)^2			
26	no frequency	else if elev< 35.8 then -28				else if Ø<12 then -18			
27	reuse	else if elev≤ 90 then 10.86-25 log(elev)				else if Ø<50 then -24			
28	Hub TX omni	Omni in azimith				else if Ø<90 then -30			
29						else if Ø≤180 then 99.84-66.44 log(Ø)			

Table 2.3.1 - Signal Parameters WG1/52 (Rev 5) 9/20/94

	A	B	C	D	E	F	G	H	I
30	Texas Instrument	Hub TX	Hub TX	Hub TX	Hub TX	Sub TX	Sub TX	Sub TX	
31	Modulation	Dig1	dig2	TV/FM	TV/AM	Dig1	Dig2&3	Dig4	
32	Pt max, dB(W)	0	-10	0	-1	0	-10	-28	
33	Gt max, dB(i)	15	15	15	15	35	35	35	
34	EIRP(rain), dB(W)	15	5	15	14	35	25	7	
35	EIRP(no rain),dB(W)	3	-7	3	10	23	13	3	
36	BW MHZ	52	5.2	17	4.2	52	5.2	5.2	
37	EIRPo max, dB(W)	-62.2	-62.2	-57.3	-52.2	-42.2	-42.2	-60.2	
38	EIRPo(no rain),dB(W)	-74.2	-74.2	-69.3	-56.2	-54.2	-54.2	-64.2	
39	-TX point loss, dB	-3.0	-3.0	-3.0	-3.0	-1.0	-1.0	-1.0	
40	Freq, MHz	29,400	29,400	29,400	29,400	29,400	29,400	29,400	
41	Cell radius, km	5.0	5.0	5.0	1.0	5.0	5.0	1.0	
42	-Lbf, dB	-135.8	-135.8	-135.8	-121.8	-135.8	-135.8	-121.8	
43	-Rain attn, dB	-15.0	-15.0	-15.0	-4.0	-15.0	-15.0	-4.0	
44	-RX point loss, dB	-1.0	-1.0	-1.0	-1.0	-3.0	-3.0	-3.0	
45	Gr max, dB(i)	35.0	35.0	35.0	35.0	15.0	15.0	15	
46	Pro(rain), dB(W/Hz)	-181.9	-181.9	-177.1	-147.0	-181.9	-181.9	-175.0	
47	Tr eff(8 dB nf), K	1830.0	1830.0	1830.0	1830.0	1830.0	1830.0	1830.0	
48	No, dB(W/Hz)	-196.0	-196.0	-196.0	-196.0	-196.0	-196.0	-196.0	
49	Pro/No(rain), dB	14.0	14.0	18.9	48.9	14.0	14.0	21.0	
50	Pro/No(no rain), dB	17.0	17.0	21.9	48.9	17.0	17.0	21.0	
51	C/(N+I) req, dB	13	13	18	45	13	13	13	
52	Margin Clear Air	4.0	4.0	3.9	3.9	4.0	4.0	8.0	
53	Margin Rain	1.0	1.0	0.9	3.9	1.0	1.0	8.0	
54	HUB G(elev) - Gmax	off boresight	Installed Elev. Angle			SUB G(Ø)-Gmax			
55	0 dB	0°	-2°			if Ø<2 then 0			
56	0 dB	3°	1°			else if Ø<4.75 then 16-8Ø			
57	-15 dB	9°	7°			else if Ø≤8.5 then -14.4-1.6Ø			
58	-20 dB	14°	12°			else if Ø<11.5 then -28			
59	-22 dB	18°	16°			else if Ø< 14.5 then -20.33-0.667Ø			
60	-26 dB	22°	20°						
61	-26 dB	>=29°	>=27°			else if Ø≤180 then -30			

Table 2.3.1 - Signal Parameters WG1/52 (Rev 5) 9/20/94

	A	B	C	D	E	F	G	H	I
62									
63		36 sectors	36 sectors	36 sectors	Sub TX	Sub TX	Sub TX		
64	Video/phone	Hub TX	Hub TX	Hub TX	QPSK	16QAM	256QAM		
65	Modulation	TV/AM	TV/FM	Dig QAM					
66	Pt max, dB(W)	-4.8	0.1	-4.8	-20	-10	0		
67	Gt max, dB(i)	29.7	29.7	29.7	38	38	38		
68	EIRP(rain), dB(W)	24.9	29.8	24.9	18	28	38		
69	EIRP(no rain),dB(W)	13.9	18.8	13.9	10	18	28		
70	BW MHZ	6	20	6	1.544	22.5	100		
71	EIRPo max, dB(W)	-42.9	-43.2	-42.9	-43.9	-45.5	-42.0		
72	EIRPo(no rain),dB(W)	-53.9	-54.2	-53.9	-51.9	-55.5	-52.0		
73	-TX point loss, dB	0.0	0.0	0.0	0.0	0.0	0.0		
74	Freq, MHz	29,400	29,400	29,400	29,400	29,400	29,400		
75	2 x Cell radius, km	1.6	1.6	1.6	1.6	1.6	1.6		
76	-Lbf, dB	-125.9	-125.9	-125.9	-125.9	-125.9	-125.9		
77	-Rain attn, dB	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8		
78	-RX point loss, dB	0.0	0.0	0.0	0.0	0.0	0.0		
79	Gr max, dB(i)	38	38	38	29.9	29.9	29.9		
80	Pro(rain), dB(W/Hz)	-136.6	-136.9	-136.6	-145.7	-147.4	-143.8		
81	Tr eff(7.5 dB nf), K	1630	1630	1630	1630	1630	1630		
82	No, dB(W/Hz)	-196.5	-196.5	-196.5	-196.5	-196.5	-196.5		
83	Pro/No(rain), dB	59.9	59.5	59.9	50.8	49.1	52.6		
84	Pro/No(no rain), dB	54.7	54.3	54.7	48.6	44.9	48.4		
85	C/(N+I) req, dB	52	24	15.6	13	27	32		
86									
87		HUB G(elev) - Gmax, vertical plane							
88		if elev<1 then 0				SUB G(Ø) - Gmax			
89		else if elev<8.5 then 4.81 - 4.81 x elev				if Ø< 2.89 then -3(Ø/1)^2			
90		else if elev≤ 90 then -10-28 log(elev)				else if Ø<4.5 then -25			
91		Horiz plane (36 sectors)				else if Ø<90 then -16.28-18 log(Ø)			
92		if Ø< 11.8 then -3(Ø/5)^2.5				else if Ø ≤ 180 then -52			
93		else if Ø ≤ 180 then -10-14.5 log(Ø)							

Table 2.3.1 - Signal Parameters WG1/52 (Rev 5) 9/20/94

	A	B	C	D	E	F	G	H
1		ACTS	ACTS	ACTS	Spaceway	Teledesic		
2		USAT-X	HDR	T1-VSAT		TSL	GSL	
3	Uplink				QPSK	QPSK	8PSK	
4	Frequency	29.4	29.4	29.4	29.4	29.4	29.4	GHz
5	Path length	38,000	38,000	38,000	38,000	1,021	1,021	km
6	Trans. Rate	0.0048	700	27.5	0.384	0.225	191	Msps
7	Bandwidth	0.0048	700	27.5	0.384	0.275	95.5	MHz
8	Pt	-9.5	19.8	10.8	-5.2	-1.9	7.9	dB(W)
9	Gt(max)	36.8	58.0	49.1	49.1	36.0	50.0	dB(i)
10	EIRP	27.3	77.8	59.9	43.9	34.1	57.9	dB(W)
11	EIRPo	-9.5	-10.7	-14.5	-11.9	-20.3	-21.9	dB(W/Hz)
12	-pol. loss	0.0				-0.5	-0.5	dB
13	-pointing loss	-0.8	-1.5			-0.5	-0.5	dB
14	-atmos loss	-0.3	-0.3			-1.3	-1.3	dB
15	-rain loss	-3.2	0.0	0.0	0.0	-19.0	-19.0	dB
16	-Lbf	-213.4	-213.4	-213.4	-213.4	-182.0	-182.0	dB
17	-pointing loss	-1.8	0.0	0.0	-4.0	-2.0	-0.5	dB
18	Gr(max)	46.1	46.1	46.1	46.1	32.0	41.0	dB(i)
19	Pro	-182.9	-179.8	-181.8	-183.2	-193.6	-184.7	dB(W/Hz)
20	Tr	1,288	1,288	1,288	575	602	602	kelvins
21	No	-197.5	-197.5	-197.5	-201.0	-200.8	-200.8	dB(W/Hz)
22	Pro/No	14.6	17.7	15.7	17.8	7.2	16.1	dB
23	C/No	51.4	106.2	90.1	73.6	61.6	95.9	dB(1/Hz)
24	-impl. loss	-2	-2	-2	-2	-2	-2	dB
25	Eb/No	12.6	15.7	13.7	15.8	6.1	11.1	dB
26	Io interference limit	-211	-211	-211	-214	-218.8	-218.8	dB
27	Sidelobe mask	App 29	App 29	App 29	App 29	App 29	App 29	
28	Sat. Beam width	0.9	0.9	0.9	1	53x53 km	19 km radius	degrees
29	Min Elev angle	30	30	30	30	40	40	degrees
30	Note: ACTS also provides 0.3° beamwidth				Trans rates of .768 & 1.544 also used	Trans rate may increase to 28.8 with same EIRPo	Trans rate may increase to 1533 with same EIRPo	Msps
31	0.9° beam is controlling for LMDS interference							

3.0 Description of Interference/Sharing Scenarios

To evaluate the possibilities of co-frequency sharing between the LMDS and the FSS, several scenarios need to be examined. The four major scenarios that follow model the potential interference into LMDS receivers from FSS earth stations and into FSS satellite receivers from LMDS transmitters. Two other scenarios represent potential interferences between an FSS beacon system used for power control and the LMDS systems.

3.1 FSS Earth Stations Accessing GSO Satellites Interfering into LMDS Receivers

The model for this scenario is shown in Figure 3.1.1. Two types of GSO satellite earth stations in the analysis fit this case: The proposed Hughes Spaceway System, as well as the operational NASA ACTS experimental system, as a technical proxy for future potential GEO satellite systems. The interference analysis focussed on the side-lobe and back-lobe energy that earth stations of both of these systems emit when functioning as designed, emissions that potentially interfere with LMDS transmissions at the receivers of all three LMDS systems under study.

Since the objective is to effect non-coordinated (at the time of installation) sharing between GSO satellite earth stations and LMDS, the requirement is to reduce the "protection distance" to a very small, commercially untroublesome distance. The protection distance is the minimum distance allowed between randomly installed and un-coordinated FSS earth stations and LMDS receivers such that both can be expected to operate without harmful interference from the other.

3.2 FSS Earth Stations Accessing non-GSO Satellites Interfering into LMDS Receivers

The model for this scenario is shown in Figure 3.1.2. The example NGSO FSS earth stations under study were the Teledesic Standard Terminal (TST) and the Teledesic GigaLink Terminal (TGT). The three LMDS systems were individually considered in interference and mitigation analyses as the "target" of Teledesic interference energy.

The large number of satellites in Teledesic's design permits maintaining a high look angle for the earth stations, which could help facilitiate sharing. The analysis focussed on the level of side-lobe & back-lobe energy interfering into each of the LMDS systems.