BEFORE THE
Federal Communications Commission
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Motorola Global Communications, Inc.	)	File Nos. 79-SAT-P/LA-97(63)
	)	94--98-SAT-P/LA-97
Application for Authority to	)	
Construct, Launch, and Operate	)	
the Celestri Satellite System	)	

COMMENTS OF LORAL SPACE & COMMUNICATIONS LTD.

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December 22, 1997

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0051739.01

EXECUTIVE SUMMARY

Loral's initial interference assessment reveals that Celestri will cause unacceptable interference into licensed GSO systems, including CyberStar™ (see Appendix A). Motorola's Celestri system applications do not demonstrate that sharing is feasible between Celestri and other GSO systems. Motorola must provide additional information before Loral can revise its assessment that Celestri should not be licensed using the proposed system parameters (see Appendix B).

In accordance with Commission policies, the Commission must require Motorola to demonstrate conclusively that operation of Celestri will not interfere with licensed GSO/FSS systems in the 19.7-20.2 GHz, and 29.5-30.0 GHz bands. The Commission must not allow unlicensed system proposals that have not adequately demonstrated non-interference to priority licensed services to endanger the development of licensed Ka-band GSO systems. Competing requests by NGSO systems to use the NGSO Priority Bands should not lower the level of scrutiny the Commission applies in evaluating whether an NGSO system can actually operate in the GSO Priority Bands on a secondary basis.

To adequately protect licensed GSO Ka-band systems, the Commission should support efforts to develop aggregate, multiple system, multiple entry NGSO PFD limits. If the Commission would also like to adopt single system, multiple entry PFD limits, the Commission, working together with the proponents of NGSO/FSS systems, should determine the number of NGSO systems that may be supported in the NGSO allocated bands so that the appropriate single system PFD limits can be developed while preserving the concept of a multiple system, multiple entry PFD limit that would apply.

The Commission should resolve these sharing issues as soon as possible, and at the same time in order to protect already licensed systems, and promote the rapid development of services. A defined, stable, and predictable NGSO/GSO FSS sharing/interference regulatory structure will promote the development of both services.

The Commission should address the Celestri applications only in the context of a comprehensive solution to sharing between GSO and multiple NGSO systems.

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COMMENTS OF LORAL SPACE & COMMUNICATIONS LTD.

Loral hereby submits its comments on the above-captioned applications for consideration by the Commission. Loral, a leading satellite service and system provider, is interested in this proceeding because it has been licensed by the Commission to launch and operate its GSO/FSS Ka-band system, CyberStar™, that will provide world-wide broad-band services.[1] CyberStar™ is a wireless interactive multimedia system designed to provide compressed high data-rate bi-directional digital signals in the Ka-band to both commercial and residential users via low-cost subscriber terminals. CyberStar™ will operate in the Ka-band, including the 19.7 - 20.2 and 29.5 - 30.0 GHz frequency bands that Motorola's Celestri NGSO/FSS LEO system proposes to include in its own frequency plan.[2] Because Motorola proposes to use frequency bands reserved by

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1 In the Matter of Loral Space & Communications Ltd. Application for Authority to Construct, Launch, and Operate a Ka-Band Satellite System in the Fixed-Satellite Service, *Order and Authorization,* DA 97-974 (rel. May 9, 1997); In the Matter of Assignment of Orbital Locations to Space Stations in the Ka-Band, *Order*, DA 97-967 (rel. May 9, 1997); In the Matter of Assignment of Orbital Locations to Space Stations in the Ka-band, *Order*, DA 97-2654, (rel. December 19, 1997).

2 Celestri LEO Application at p. ii.

the Commission for priority use by Ka-Band GSO/FSS systems,[3] Loral seeks to ensure that CyberStar™ is protected from harmful interference that may be caused by Celestri, or by the combination of interference that would be contributed by Celestri and other NGSO systems.

I. Regulatory Framework

The WRC-97 Goal Of Provisional Power Flux-Density Limits is to Allow GSO and NGSO Systems To Co-Exist; However, Further Study Is Needed To Ensure That These GSO Systems Are Protected From Harmful Interference Caused By NGSO Systems.

WRC-97 adopted a series of provisional PFD limits on a band-by-band basis that set forth, on a time statistical basis, the aggregate level of interference a single NGSO/FSS system may introduce into GSO/FSS systems before the interference is considered unacceptable by the GSO/FSS operator.[4] PFD limits were designed to offer the potential for NGSO/FSS and GSO/FSS systems to co-exist without resulting unacceptable interference to GSO/FSS systems. WRC-97 called for studies to evaluate the provisional PFD limits in time for the next WRC. Loral believes that only aggregate, multiple-entry PFD limits that may not be exceeded in total, regardless of the number of NGSO systems actually operating, offer the possibility for NGSO/GSO co-existence. Loral is participating in ITU-R Joint Task Group 4-9-11 and the appropriate ITU-R Study Groups, in the effort to develop satisfactory limits.

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3 See Discussion of FCC licensing priority scheme, *infra*.

4 See Resolutions COM5-18 (WRC-97), COM5-19 (WRC-97). These resolutions include provisional PFD limits that apply to CyberStar's operational bands.

GSO Systems Are The Cornerstone Of The Satellite Industry And Must Be Protected

GSO satellites systems use proven technology and have a successful technical and commercial performance record spanning more than 30 years. They are dependable, robust, effective and affordable. GSO satellite technology has evolved to encompass changes in technology, operational needs and regulatory changes, such as 2° spacing, that require that limited orbital-spectrum resources be used more efficiently . GSO satellites have grown more powerful over the years and now are able to efficiently use their assigned spectrum and provide increased services over larger geographic areas. CyberStar™ proposes to link GSO satellites into a system capable of delivering end-to-end solutions around the world. Many of the Ka-band GSO systems licensed by the Commission will employ spot-beam technology, enabling a higher level of frequency reuse than ever before while operating in a 2° spacing environment. This competitive market has many new entrants -- 14 companies received authorizations for Ka-band GSO systems in the Commission's first processing round, many of whom will enter the satellite services market for the first time. [5]

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[5] Assignment of Orbital Locations to Space Stations in the Ka-Band, *Order*, DA 97-967 (rel. May 9, 1997). New entrants have already applied for licenses in the Commission's second Ka-band processing round, which will consider applications filed as of December 22, 1997. See CAI Data Systems Ka-band Application, File no. 88-SAT-P/LA-97, filed July 2, 1997.

Pursuant To The *28 GHz Band Plan* And *Ka-Band Service Rules*, Celestri Bears The Burden Of Proving To The Commission That It Will Not Cause Any Interference To GSO Systems In Their Primary Bands, Including The 19.7 - 20.2 And 29.5 - 30.0 GHz Bands

The *28 GHz Band Plan* promotes competition in services such as Local Multipoint Distribution, NGSO Fixed Satellite, GSO Fixed Satellite, and Mobile Satellite Feeder Links, by permitting these services to develop in distinct segments of the band.[6] In its effort to promote the development of these services, the Commission kept the following objectives in mind: (1) ensuring consistency with international and domestic allocation decisions, (2) providing for coordination of new systems with existing services in the band, (3) designating discrete band segments for services which do not appear capable of sharing at the time, and (4) providing maximum flexibility for system implementation, inter-system sharing,[7] and future system growth.[8]

The Commission established discrete spectrum bands for specific types of satellite systems, and a licensing ranking scheme in which a particular service has licensing priority over another service (which must operate on a strict non-interference basis) in that particular band.[9] The *28 GHz Band Plan* assigns GSO/FSS system uplinks licensing priority with respect to

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6 In the Matter of Rulemaking to Amend Parts 1,2,21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, *First Report and Order and Fourth Notice of Proposed Rulemaking*, FCC 96-311, 11 FCC Rcd 19005 ("*28 GHz Band Plan*").

7 The Commission believes that the adoption of the 28 GHz Band Plan does not preclude the possibility of NGSO/FSS sharing. Id. at ¶ 28.

8 Id. at ¶ 41.

9 Id. at ¶ 44.

NGSO/FSS system uplinks in the 28.35 - 28.60 GHz and the 29.25 - 30.0 GHz bands.[10] GSO/FSS system downlinks are assigned licensing priority with respect to NGSO/FSS systems in the 17.7 - 18.8 GHz and 19.7 - 20.2 GHz bands.[11]

The Commission implemented its *28 GHz Band Plan* in its *Service Rules Order*.[12] In accordance with the *28 GHz Band Plan*, the *Service Rules Order* requires that any service provider proposing to operate, on a secondary basis, in a band segment in which it does not have licensing priority, such as Celestri in the 19.7-20.2 GHz and 29.5-30.0 GHz bands in which GSO FSS are primary, to operate on an unprotected non-interference basis to the priority service.[13] To ensure non-interference with the primary, priority service licensee, the Commission requires all secondary operators to submit to the Commission a technical demonstration that the secondary system can operate without causing harmful interference to satellite systems with licensing priority. In this instance, Celestri bears the burden of proving to the Commission that it will not

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10 Id. at ¶ 42. GSO/FSS system uplinks also are assigned on a co-primary basis, subject to sharing rules, with MSS feeder links in the 29.25 - 29.5 GHz band. NGSO/FSS system uplinks are assigned licensing priority only in the 28.60 - 29.1 GHz frequency band. NGSO/FSS system downlinks are assigned licensing priority only in the 18.8 - 19.3 GHz frequency band. Band Plan at ¶ 77 See In the Matter of Teledesic Corporation Application for Authority to Construct, Launch, and Operate a Low Earth Orbit Satellite System in the Domestic and International Fixed Satellite Service, 12 FCC Rcd 3154 (1997).

11 *28 GHz Band Plan* at ¶ 79.

12 In the Matter of Rulemaking to Amend Parts 1,2,21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, *Third Report and Order*, FCC 97-378, ¶¶ 39-49 (rel. Oct. 15,1997).

13 Id. at ¶ 39, 66, 71.

cause any interference to GSO systems in their primary bands, 19-7-20.2 GHz and 29.5-30.0GHz. Secondary users are required to immediately cease operations upon notification of harmful interference into any service or system that has superior status or licensing priority in a particular band segment. [14]

The Commission has determined that it is in the public interest to use the *28 GHz Band Plan* as the basis for coordinating U.S. licensed Ka-band systems internationally, and plans to do so when completing the ITU's coordination procedures.[15] Celestri, if licensed, will therefore be bound by the Commission's *28 GHz Band Plan* and *Service Rules Order* worldwide, and must not interfere with GSO/FSS systems where they are assigned priority status. Furthermore, Celestri will be precluded from entering into any exclusive arrangements with other countries that may be inconsistent with the *28 GHz Band Plan*, or foreclose other U.S. licensees from serving a foreign market.[16]

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14 Id. at ¶ 39.

15 Id. at ¶¶ 63-73.

16 Id. at ¶ 73.

GSO/FSS Systems Must Be Protected When NGSO/FSS Systems Propose To Share GSO/FSS Priority Bands

Loral supports the FCC's traditional policy of maximizing the use of scarce radio frequency spectrum for satellite systems. The Commission's pragmatic and spectrum efficient satellite regulatory policies have enabled the U.S. commercial satellite industry to flourish. However, NGSO/FSS system operators proposing to operate in the GSO/FSS "Priority Bands"[17] must afford adequate protection to Ka-band GSO systems.

In considering the Celestri application, the Commission should carefully review the effect of Celestri's performance characteristics on licensed satellite systems using the Ka-band GSO/FSS "Priority Bands." Loral believes that the Commission should not license NGSO/FSS systems that would effectively preclude use of the GSO orbital arc by GSO/FSS systems.

The Commission Must Not Allow Unlicensed System Proposals That Do Not Adequately Demonstrate Non-Interference To Priority Licensed Services To Endanger The Development Of Licensed Ka-Band GSO Systems

The present Ka-band licensees have been developing their systems for more than four years and in May 1997, the Commission authorized thirteen GSO FSS companies to construct, launch, and operate their proposed GSO systems, accounting for a proposed total investment of more than $23 billion and more than 75 GSO satellites.[18]

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17 The GSO/FSS "Priority Bands" with respect to NGSO/FSS are the 17.7 - 18.8, 19.7 - 20.2, 28.35 - 28.6, 29.25 - 29.5, and 29.5 - 30.0 GHz bands.

18 In the Matter of Assignment of Orbital Locations to Space Stations in the Ka-Band, *Order*, DA 97-967 (rel. May 9, 1997).

Since grant of the Ka-band licenses in May, Loral and other Ka-band licensees have relied on the Commission's policies and invested substantial resources to further develop and implement their Ka-band systems. The Commission must not allow an unlicensed system proposal, like Celestri, that has not adequately demonstrated the potential to operate on a non-interference basis with respect to priority licensees in certain bands, to dictate the development of those licensed Ka-band systems.

Application of any other policy would allow unlicensed systems to dictate the design of licensed systems. This policy would not be in the public interest since licensees would have to continuously modify their system design to account for unlicensed systems, delaying the implementation of services, and possibly affecting their quality as well as discouraging investment and undermining business plans. Licensees, including Loral, relying on the Commission's actions, have invested millions of dollars to develop their licensed systems, as Loral already has, would suffer higher costs as a result of redesign, and would encounter significant delays in providing service. An untested system such as Celestri has the burden to prove to the Commission and the Ka-band GSO satellite licensees that its interference mitigation techniques will not harm licensed systems in which millions of dollars have already been invested and in which billions of dollars are to be invested. Finally, an FCC license would not mean anything if new proposals continuously jeopardized its development. The Commission should promote a stable regulatory environment and protect its licensees. This approach will foster the rapid development and deployment of new services, and is in the public interest.

WRC-97 Provisional PFD Limits Must Ensure NGSO Protection In the Context of Multiple NGSO Systems

In order to adequately protect its licensees, the Commission should develop, as soon as possible, the regulatory framework for allowing multiple NGSO systems to operate without endangering GSO licensed systems.[19] Loral supports the development of aggregate PFD limits on a band-by-band basis for NGSO systems to avoid interference to GSO systems.[20] While GSO/NGSO sharing may be achieved by defining a set of NGSO power flux-density limits that must be tolerated by GSO systems, it is imperative that the limits developed are aggregate, multiple entry NGSO limits rather than single entry NGSO limits without corresponding multiple system, multiple entry limits. The adoption of single entry limits alone, as WRC-97 has done on a provisional basis, will protect GSOs from one NGSO system, but will not protect GSOs if more than one NGSO system is implemented.

Before the Commission permits any NGSOs to operate on a secondary basis in the GSO Priority Bands, the Commission should first ensure that there are aggregate, multiple system, multiple entry[21] NGSO PFD limits that will adequately protect GSO systems. By establishing

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19 As evidenced by the current interest in NGSO systems, and the instant Celestri applications, several proponents plan to implement NGSO systems.

20 See WRC-97 Resolutions COM5-18, COM5-19. See Application of SkyBridge LLC, File Nos. 48-SAT-P/LA-97, 89-SAT-AMEND-97; Comments of Loral Space & Communications Ltd., filed Dec. 15, 1997.

21 In developing single system, multiple entry PFD limits, the Commission should determine the number of NGSO systems that may ultimately be implemented without jeopardizing the integrity of already licensed systems. A single entry, single system PFD limit which does not take into account aggregate NGSO limits, or establish the maximum number of NGSO systems would, if set too high, eventually result in unacceptable interference to GSO systems.

now the maximum level of interference that all NGSO systems (whether operational, licensed but unbuilt or proposed) may contribute into GSO systems, as well as the number of NGSO systems that may be licensed in shared bands, the Commission will enable multiple NGSO systems to exist without causing unacceptable interference into GSO systems.[22]

If the Commission does not adopt such a policy, NGSO operators would not be able to coordinate with GSO operators. Coordination would have to be performed on a case-by-case basis as each new NGSO system sought to use GSO shared bands. GSO operators, who could not know how many NGSO systems would eventually be implemented, would therefore not be able to evaluate single system, multiple entry limits in any given NGSO/GSO coordination. Furthermore, a NGSO single entry limit would result in the Commission effectively deciding that it would only account for one NGSO system in the GSO priority bands.

Loral therefore supports the development and adoption of aggregate, multiple system, multiple entry NGSO power flux density limits, on a band-by-band basis, to protect GSO systems. The Commission and the satellite industry must, through the appropriate ITU Study Group processes, industry studies, and domestic rulemakings, develop aggregate power flux-density limits regardless of the total number of NGSO systems implemented. The total number of NGSO systems that can coexist without causing interference to GSOs will be determined by the precise

22 For example, the Commission could establish the number of NGSO systems to be licensed such that interference with existing licensees does not occur, and determine (1) the overall multiple system, multiple entry PFD limits, as well as (2) the single system, multiple entry PFD limits.

coordination techniques undertaken by NGSO operators such that the aggregate PFD limits are never exceeded when the interference from all NSGO systems is considered.

II. Initial Assessment Of Celestri NGSO Interference Into GSO Systems

The interference mitigation information provided by Celestri is insufficient to conduct a complete analysis. Its proposed parameters, however, seem to far exceed reasonable levels that might permit effective spectrum sharing between Celestri and a GSO system.

Celestri Will Cause Unacceptable Levels Of Interference Into GSO Systems, Including CyberStar™

Based on the available information in the Celestri application, Loral has performed an initial interference assessment that is attached as Appendix A. Loral's initial assessment[23] concludes that Celestri causes interference into GSO systems including CyberStar™ at levels many times greater, and for longer periods of time, than can be tolerated by GSO systems operating with acceptable performance and quality of service levels.[24]

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23 NGSO/GSO sharing presents complex technical issues. Thus, subsequent to the conslusion of WRC-97, Loral and others requested an additional 60 day extension of time in which to file comments with respect to Celestri's application.

24 Loral notes that coordinating operation of Celestri with co-frequency NGSO/FSS systems like the licensed Teledesic System presents complex technical issues. Loral wishes to emphasize that it takes no position with respect to Motorola's request to use the NGSO/FSS "Priority Bands." However, the Commission should not allow NGSO/NGSO sharing issues to unduly influence its consideration of whether to permit Motorola to use the GSO/FSS "Priority Bands" on a secondary basis.

Motorola Must Provide Additional Information Before Loral Can Revise Its Assessment That Celestri Should Not Be Licensed Using The Proposed System Parameters

Motorola's Celestri system applications do not demonstrate that sharing is feasible between Celestri and other GSO systems. On the contrary, the applications highlight instances in which Celestri will cause unacceptable levels of interference to GSO systems and CyberStar™. Loral is willing to work with Motorola to better assess the potential for sharing the GSO Priority Bands with Celestri. However, before it can do so, Loral requests that the Commission require Motorola to supply the additional information set forth in Appendix B.

III. Recommendations

Based on this initial assessment, Loral respectfully urges the Commission to consider the following recommendations:

- In accordance with its stated policies, as expressed in the *28 GHz Band Plan* and *Ka-band Service Rules*, the Commission must require Motorola to demonstrate conclusively that operation of its Celestri LEO/GSO system will not interfere with licensed GSO/FSS systems in the 19.7 - 20.2 GHz, and 29.5 - 30.0 GHz bands.

- Based on the available information in the Celestri Application, Loral has performed an initial interference assessment that is attached as Appendix A. Celestri causes interference into GSO systems and CyberStar™ at levels many times greater, and for longer periods of time, than acceptable performance parameters. Motorola's 0.3m antenna performance specification requires use of power levels that exceed interference levels for co-frequency co-existence with GSO systems and which result in violating even the provisional ITU Ka-band limits.

- Motorola's simulation study is inadequate and does not establish that the Celestri system will not interfere with GSO systems in the GSO Priority Bands. Motorola has failed to provide sufficient information and must be required to provide the information requested in Appendix B.

- The proposed Celestri GSO power levels are approximately 10 dB higher than other GSO systems and should be brought into line with power levels of other GSO system operators to facilitate inter-system coordination.

- Because Celestri's power control adjustment will have increased transmitted satellite power in the entire beam to compensate for rain in part of the beam, the higher EIRP (rain) will be received by some CyberStar™ earth terminals which are deployed throughout the entire geographic area covered by a given Celestri NGSO beam, thus causing unacceptable interference.

- GSO/FSS systems must remain fully protected when NGSO/FSS systems propose to share the GSO/FSS priority bands; the Commission must not allow unlicensed system proposals that have not adequately demonstrated non-interference to priority licensed services to endanger the development of licensed Ka-band GSO systems.

- In order to adequately protect licensed GSO Ka-band systems, the Commission should support efforts to develop aggregate, multiple system, multiple entry NGSO PFD limits. If the Commission would also like to adopt single system, multiple entry PFD limits, the Commission, working with the proponents of NGSO/FSS systems, should determine the number of NGSO systems that may be supported in the NGSO/FSS allocated bands so that the appropriate single system PFD limits can be developed while preserving the concept of a multiple system, multiple entry PFD limit that would apply.

- The Commission should resolve all NGSO/NGSO sharing issues as soon as possible, and at the same time. Competing requests by NGSO systems to use the NGSO Priority Bands should not lower the level of scrutiny the Commission applies in evaluating whether an NGSO system can actually operate in the GSO Priority Bands on a secondary basis.

- A defined NGSO/GSO FSS sharing/interference regulatory structure will promote the development of both services by providing a stable and predictable regulatory environment.

IV. Conclusion

For the reasons outlined in these Comments and Appendices, Loral urges the Commission to adopt Loral's recommendations with respect to Motorola's request to use the GSO Priority Bands for the NGSO component of the Celestri system and to address the applications only in the context of a comprehensive solution to sharing between GSO and multiple NGSO systems.

Respectfully submitted,

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December 22, 1997

ENGINEERING CERTIFICATION

I, Edmund Habib, hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in these Comments and all attachments and appendices hereto, that I am familiar with Part 25 of the Commission's Rules, that I have either prepared or reviewed the engineering information submitted in these Comments and appendices hereto, and that it is complete and accurate to the best of my knowledge and belief.

Respectfully submitted,

[signature]

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Appendix A - Interference Analysis

Motorola's Celestri NGSO system, despite utilizing mitigation techniques identified by Motorola, causes interference into GSO systems (including CyberStar™) at levels many times greater and for periods of time far exceeding acceptable performance degradation to GSO customers. Loral demonstrates below, using Celestri performance characteristics along with standards and/or recommendations established by industry, the ITU and/or the FCC, the extent of that unacceptable interference.

The following is a summary of the pertinent data taken from the Celestri NGSO application:

Table A-1 Celestri Performance Parameters

	0.3 Meter Antenna		0.85 Meter Antenna		1.2 Meter Antenna		1.8 Meter Antenna	
	Clear Sky	Rain	Clear Sky	Rain	Clear Sky	Rain	Clear Sky	Rain
Satellite amplifier power (watts)	10.0	22.4	1.0	6.4	1.4	8.7	1.0	5.0
Data rate (Mbps)								
Downlink	16.4	16.4	16.4	16.4	51.8	51.8	155.5	155.5
Uplink	2.0	2.0	10.0	10.0	51.84	51.84	155.52	155.52
Antenna gain (dB)	32.8	32.8	32.8	32.8	32.8	32.8	37.4	37.4
EIRP (dBw)								
Downlink	41.3	44.8	31.3	39.4	32.8	40.7	35.9	42.9
Uplink	33.2	39.0	39.8	52.0	48.5	60.7	50.8	60.4

Celestri relies primarily on satellite diversity to maintain communication links while, at the same time, mitigating interference into GSO systems sharing the same frequency band. The mitigation technique works such that whenever the vector from the Celestri NGSO earth terminal to the Celestri system satellite is within $\pm 4°$ of the geosynchronous arc, ("the exclusion zone") transmissions cease from both that satellite beam and the earth terminals served by that beam. In most cases, the earth terminals can then link up with an alternate Celestri satellite and can return to the original satellite once it is out of the "exclusion zone."

In order to assess the impact of the Celestri system upon the CyberStar™ GSO system, Loral has converted the PFD performance described by Celestri into an Effective Power Flux-Density (EPFD)— the amount of interference the CyberStar™ system will experience as a result of sharing spectrum with the Celestri NGSO system.

EPFD is expressed in dB watts per square meter per 1 MHz and measures the effective power arriving at the GEO arc from the Celestri earth terminals and the effective power arriving at the GSO (CyberStar™) earth terminals from the Celestri satellites. EPFD is defined as the power either transmitted or arriving at a specified off axis angle from the main pointing vector of the earth terminal. For example, if a signal level of -110 $dBw/m^2/MHz$ at 20 GHz arrives at the center of the main beam of a 0.7m antenna which has a main beam gain of 40 dBi, then using the formula (ITU-R Rec. S.465-5 and as referenced in Motorola's application) for off axis gain $=52 - 10 \log (D/\lambda) - 25 \log \theta$, which for 4 degrees becomes approximately 20 dBi, then a different antenna pointing 4 degrees away from the first antenna will perceive that signal as reduced by the difference in gain (namely 40-20) of 20 or effectively believes it is receiving a signal level of (-110-20) - 130 $dBw/m^2/MHz$.

In Table 1 below Loral shows the power flux density of a downlink beam of the Celestri NGSO satellite and calculates the effective impact to a CyberStar™ ground station. For purposes of the interference assessment the worst case scenario of Celestri's 0.3-meter antenna transmitting at 16.384 Mbps during rain conditions was chosen.

TABLE 1

CELESTRI LINK BUDGET PERFORMANCE SUMMARY

NGSO Satellite into 0.7 Meter GSO Antenna
0.3 Meter Antenna NGSO Earth Terminal at 16.384 Mbps
20 GHz Downlink

	Clear Sky	Rain Conditions	
Satellite Amplifier Power	10.0 w	22.4 w	Given transmitter power level before losses
Power	10.0 dBw	13.5 dBw	Arithmetic translation from power level to dBw
Transmitter Loss	-1.5 dB	-1.5 dB	Given Celestri satellite performance
Antenna Gain	32.8 dB	32.8 dB	Given Celestri satellite performance
EIRP (Power leaving the satellite)	41.3 dBw	44.8 dBw	Sum of power, losses and antenna gain
Atmosphere Loss	-1.2 dB	-1.2 dB	Clear sky atmospheric impact
Rain attenuation	0.0 dB	-3.7 dB	Impact of rain conditions
Pointing error	-1.5 dB	-1.5 dB	Assumed Polarization/Attitude Losses
Bandwidth conversion	-12.7 dB/MHz	-12.7 dB/MHz	Data Rate Bandwidth Ratio To 1 MHz*
Spreading loss for NGSO orbit	-139.5 dB/m^2	-139.5 dB/m^2	Translation into one sq. meter from NGSO Satellite to range of 2,660 Km
Power Flux Density (Power density at the ground)	-113.6 dB(w/m^2/1MHz)	-113.8 dB(w/m^2/1MHz)	Agrees with NGSO Celestri Appendix A
Impact on GSO Ground Terminal			
Rain attenuation add back	0	3.7 dB	No rain on GSO terminal
Pointing error add back	1.5 dB	1.5 dB	No polarization/attitude impact at GSO terminal
Off-axis advantage (4 degrees)	-20.3 dB	-20.3 dB	CyberStar™ 0.7m antenna on-axis gain = 40.6 with offset using 52 - 10 log (70/1.5) = 20.3 from ITU-R S.465-5 (See Assumption #2)
Effective Power from Celestri NGSO into GSO (EPFD) 0.7 m antenna (4 degrees off axis)	-132.4 dB(w/m^2/1MHz)	-128.9 dB(w/m^2/1MHz)	

* Assumed Date Rate Bandwidth = BW = DR x 1.1365 (Block Coding) x 1/2 (QPSK) x 2/1 (FEC Coding).

Assumptions:

1. The worst case Celestri NGSO down-link interference results from the 16.384 Mb/s transmission to the Celestri NGSO 0.3 m earth terminal.

2. The off-axis receive antenna gain is computed using the forumula given in Rec. ITU-R S.465-5 which are:

For $D/\lambda < 100$

$G = 52 - 10 \log (D/\lambda) - 25 \log \theta$	dBi	for $(100\lambda/D)^\circ$	$\leq \theta < 48^\circ$
$G = 10 - 10 \log (D/\lambda)$	dBi	for	$48^\circ \leq \theta < 180^\circ$

For $D/\lambda > 100$

$G = 32 - 25 \log \theta$	dBi	for θmin	$\leq \theta < 48^\circ$
$G = 10 - 10 \log (D/\lambda)$	dBi	for	$48^\circ \leq \theta < 180^\circ$

where = 1° or $100\ \lambda/D$ degrees, whichever is the greater.

3. CyberStar™ includes the downlink rain power values in assessing the interference potential of the Celestri system on CyberStar™ because when it is raining on any Celestri NGSO earth station it is most likely not raining at all the GSO earth terminals within the given NGSO beam. Nevertheless, because Celestri's power control adjustment will have increased transmitted satellite power in the entire beam to compensate for rain in part of the beam, the higher EIRP (rain) will be received by some CyberStar™ earth terminals which are deployed throughout the entire geographic area covered by a given Celestri NGSO beam, thus causing unacceptable interference.

4. For the Celestri antenna these are:

0.3m antenna	Gtr. = 22.23 dBi or 22.23 dBi
0.85m antenna	Gtr. = 17.66 dBi or 17.7 dBi
1.2m antenna	Gtr. = 16.95 dBi or 17.0 dBi
1.8m antenna	Gtr. = 16.95 dBi or 17.0 dBi

Appendix A of the Celestri application provided data in Table A-1 that is used for the demonstration. In that table the PFD for the Celestri system is given in $dBw/m^2/MHz$ as -113.64 clear sky and as -113.84 in rain conditions. The performance numbers provided by Celestri translate as effective PFD for the CyberStar™ GSO 0.7 meter antenna, which has a has a receive gain of 40.6 dBi into levels at -132.4 dB $(w/m^2/1MHz)$ and -128.9 dB $(w/m^2/1MHz)$ for clear sky and rain condition scenarios respectively. These levels are well above any recommended or proposed numbers and are significantly beyond any feasible sharing approach for Ka-band systems. For comparison at WRC-97, limits of -145 dB$(w/m^2/1MHz)$ were discussed as provisional limits for NGSO levels. At the very least it is expected that a secondary service in this portion of the band will not exceed the provisional limits recently established.

By substituting, in Table 1, the performance variables provided in the Celestri Application, Loral was able to create a EPFD budget for various scenarios and assess the potential impact on a GSO system. A summary of the EPFD impact is shown in Table 2. Worksheets documenting Loral's calculations are attached at the end of this Appendix.

TABLE 2
EFFECTIVE POWER FROM CELESTRI NGSO INTO GSO SYSTEM*
(in dBw/m²/1MHz)

NGSO Antenna Diameter	Downlink (Clear Sky)	Downlink (Rain)*	Uplink (Clear Sky)	Uplink Rain (Rain)
0.3 m	-132.4	-128.9	-147.1	-141.3
0.85 m	-142.4	-134.3	-162.2	-150.0
1.2 m	-145.9	-138.0	-163.9	-151.7
1.8 m	-146.5	-139.5	-168.1	-158.5

Note: The applicable provisional limits by the ITU are -140 downlink and -150 for uplink

Comparing the provisional limits numbers to those in the uplink and downlink off axis values it appears that there may be sufficient single entry protection for the uplink with Celestri's proposed cutoff of ±4 degrees for antennas other than 0.3 meters in diameter. However, none of the downlink values provide sufficient protection to GSO systems.

Analysis of Motorola Simulation Study

On page 8 of the Celestri Application Figure 2-4 Motorola provides a sample of "time history of interference from Celestri LEO System into GSO Network without Mitigation." This is a graph of Interference to a reference Noise Density (Io/No) as function of time for downlink and uplink. A copy of this graph is shown below in Figure 2-4.

The Noise Density reference is reportedly taken from the example GSO system referred to in Table 2-1 and Table 2-2. However, it is not clear that this is the case because Motorola notes on page 7 of its proposal that the 0 dB level referred to in Figures 2-5 and 2-6 is only for illustration purposes.

*See Assumptions p. A-4

On page 12, Figure 2-10 of its proposal, Motorola provides the same time history when its proposed mitigation technique of cutting off transmission at ± 4 degrees from the GEO arc is applied. Loral has added to Motorola's graph the calculated EPFD/MHz for its 0.3m communication link for both the uplink and downlink from Table 2. For the uplink, the EPFD is -147.1 dBw/m^2/MHz and for the downlink the EPFD is -128.9 dBw/m^2/MHz. Loral has also added to the graph the WRC-97 COM5-18 & COM5-19 proposed threshold values that should not be exceeded for given percentages of time. If one extends the graph both to the left and the right it shows that the -140 dBw/m^2/MHz threshold is exceeded for a total of approximately 60 seconds and the -150 dBw/m^2/MHz is exceeded for a much longer time. The actual statistics of how often this happens cannot be determined without a great deal more information from Motorola such as details of the antenna patterns, coverage, and assignment of GSO bands to the individual beams (See Appendix 13). Despite the lack of important details and information in Motorola's proposal, there is sufficient evidence to place Motorola's mitigation design in question and for the Commission to require Motorola to provide additional information and prove that Celestri can operate on a non-interference basis with respect to GSO systems.

Figure 2-3
Time History of Interference from GSO Network into Celestri LEO System Without Mitigation

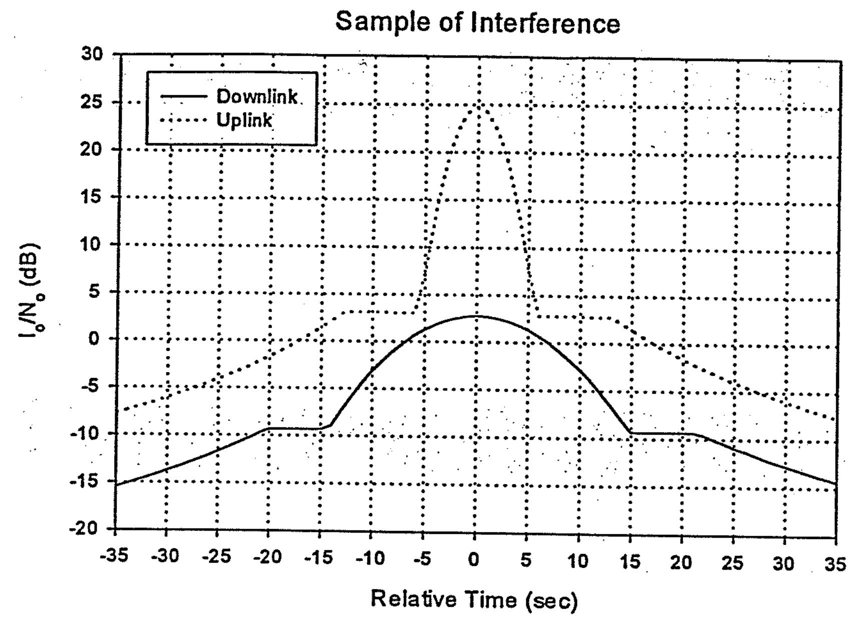


Figure 2-4
Time History of Interference from Celestri LEO System into GSO Network Without Mitigation

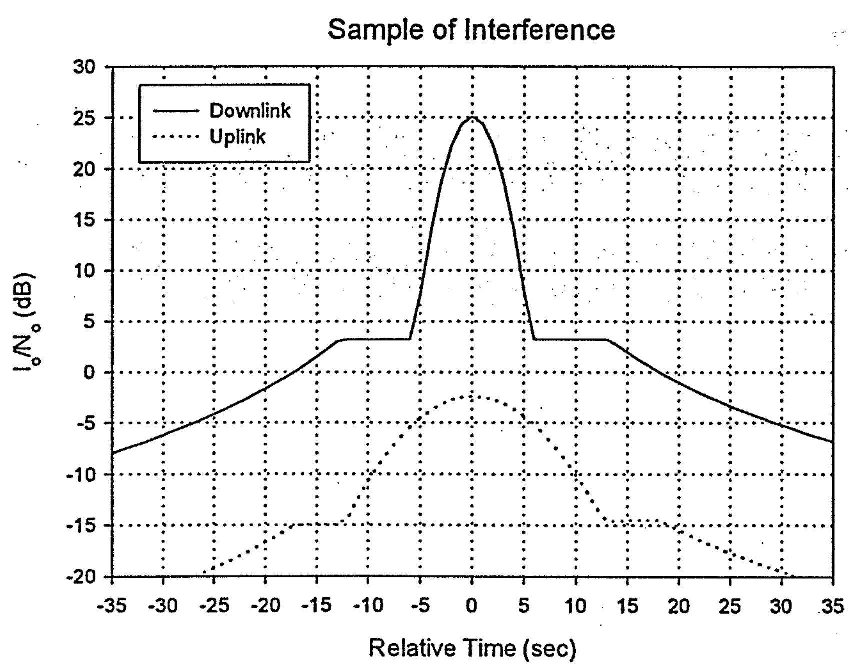


Figure 2-9
Time History of Interference from GSO Network
into Celestri LEO System

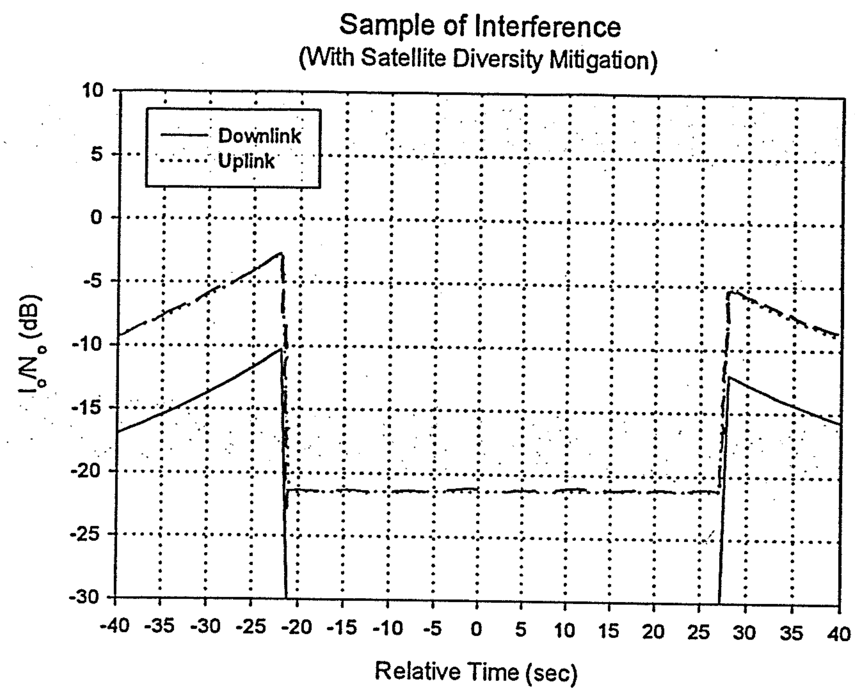
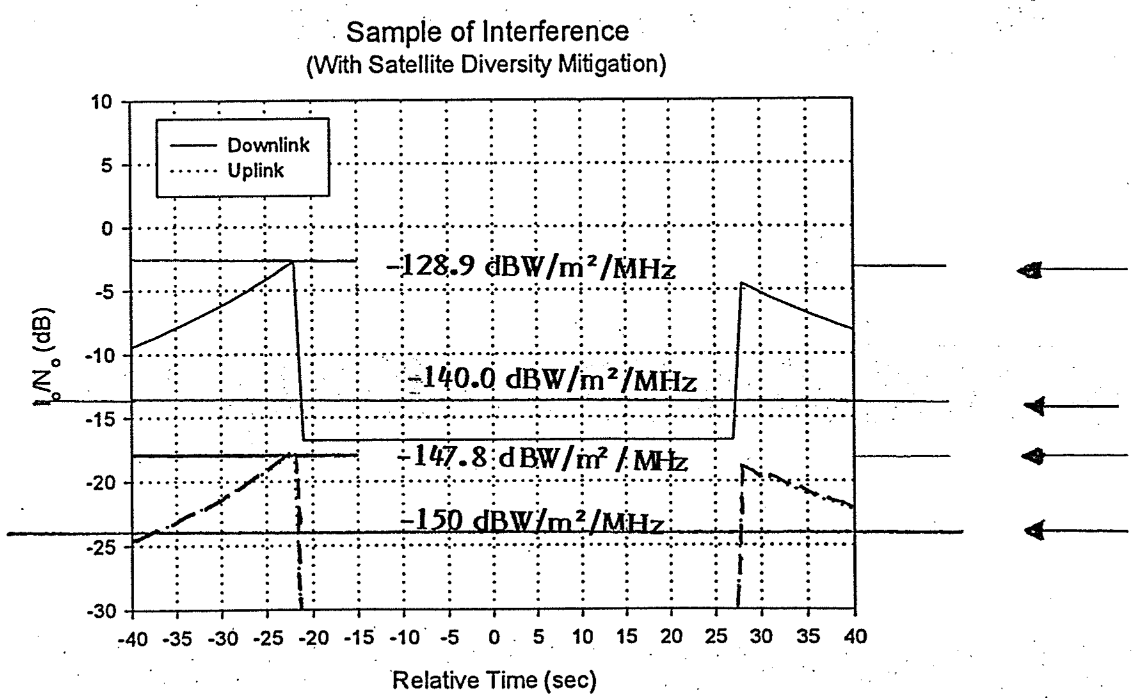


Figure 2-10
Time History of Interference from Celestri LEO System
into GSO Network



The interference mitigation information provided by Celestri is insufficient to conduct a complete analysis. Its proposed parameters, however, seem to far exceed reasonable levels that might permit effective spectrum sharing between Celestri and a GSO system.

The interference analysis simulation performed by Motorola only considers the impact on GSO systems of a single entry system (Celestri). Motorola's analysis must account for additional NGSO systems operating at the same time (e.g., Teledesic GigaLink terminals, future systems, etc.). This requires Motorola to reevaluate its assumptions for link requirements and will cause some redesign of link power or antenna diameter requirements.

In order to do the proper interference analysis, more information is required. Loral has indicated some of the information required in Appendix B, attached hereto.

TABLE 3

CELESTRI LINK BUDGET PERFORMANCE SUMMARY WORKSHEET

NGSO Satellite into 0.7 Meter GSO Antenna
0.3 Meter Antenna NGSO Earth Terminal at 16.384 Mbps
20 GHz Downlink

	Clear Sky	Rain Conditions	
Satellite Amplifier Power	10.0 w	22.4 w	Given transmitter power level before losses
Power	10.0 dBw	13.5 dBw	Arithmetic translation from power level to dBw
Transmitter Loss	-1.5 dB	-1.5 dB	Given Celestri satellite performance
Antenna Gain	32.8 dB	32.8 dB	Given Celestri satellite performance
EIRP (Power leaving the satellite)	41.3 dBw	44.8 dBw	Sum of power, losses and antenna gain
Atmosphere Loss	-1.2 dB	-1.2 dB	Clear sky atmospheric impact
Rain attenuation	0.0 dB	-3.7 dB	Impact of rain conditions
Pointing error	-1.5 dB	-1.5 dB	Assumed Polarization/Attitude Losses
Bandwidth conversion	-12.7 dB/MHz	-12.7 dB/MHz	Data Rate Bandwidth Ratio To 1 MHz*
Spreading loss for NGSO orbit	-139.5 dB/m^2	-139.5 dB/m^2	Translation into one sq. meter from NGSO Satellite to range of 2,660 Km
Power Flux Density (Power density at the ground)	-113.6 dB(w/m^2/1MHz)	-113.8 dB(w/m^2/1MHz)	Agrees with NGSO Celestri Appendix A
Impact on GSO Ground Terminal			
Rain attenuation add back	0	3.7 dB	No rain on GSO terminal
Pointing error add back	1.5 dB	1.5 dB	No polarization/attitude impact at GSO terminal
Off-axis advantage (4 degrees)	-20.3 dB	-20.3 dB	CyberStar™ 0.7m antenna on-axis gain = 40.6 with offset using 52 - 10 log (70/1.5) = 20.3 from ITU-R S.465-5 (See Assumption #2)
Effective Power from Celestri NGSO into GSO (EPFD) 0.7 m antenna (4 degrees off axis)	-132.4 dB(w/m^2/1MHz)	-128.9 dB(w/m^2/1MHz)	

* Assumed Date Rate Bandwidth = BW = DR x 1.1365 (Block Coding) x 1/2 (QPSK) x 2/1 (FEC Coding).

TABLE 4

CELESTRI LINK BUDGET PERFORMANCE SUMMARY WORKSHEET

NGSO Satellite into 0.7 Meter GSO Antenna
0.85 Meter Antenna NGSO Earth Terminal at 16.384 Mbps
20 GHz Downlink

	Clear Sky	Rain Conditions	
Satellite Amplifier Power	1.0 w	6.4 w	Given transmitter power level before losses
Power	0.0 dBw	8.1 dBw	Arithmetic translation from power level to dBw
Transmitter Loss	-1.5 dB	-1.5 dB	Given Celestri satellite performance
Antenna Gain	32.8 dB	32.8 dB	Given Celestri satellite performance
EIRP (Power leaving the satellite)	31.3 dBw	39.4 dBw	Sum of power, losses and antenna gain
Atmosphere Loss	-1.2 dB	-1.2 dB	Clear sky atmospheric impact
Rain attenuation	0.0 dB	-7.1 dB	Impact of rain conditions
Pointing error	-1.2 dB	-1.2 dB	Assumed Polarization/Attitude Losses
Bandwidth conversion	-12.7 dB/MHz	-12.7 dB/MHz	Data Rate Bandwidth Ratio To 1 MHz*
Other unknown margin	-0.3 dB	-0.4 dB	Plug to get to Celestri number
Spreading loss for NGSO orbit	-139.5 dB/m^2	-139.5 dB/m^2	Translation into one sq. meter from NGSO Satellite to range of 2,660 Km
Power Flux Density (Power density at the ground)	-123.6 dB(w/m^2/1MHz)	-122.7 dB(w/m^2/1MHz)	Agrees with NGSO Celestri Appendix A
Impact on GSO Ground Terminal			
Rain attenuation add back	0	7.1 dB	No rain on GSO terminal
Pointing error add back	1.2dB	1.2 dB	No polarization/attitude impact at GSO terminal
Margin/unknowns add back	0.3 dB	0.4 dB	Factors not relevant to GSO
Off-axis advantage (4 degrees)	-20.3 dB	-20.3 dB	CyberStar™ 0.7m antenna on-axis gain = 40.6 with offset using 52 - 10 log (70/1.5) = 20.3 from ITU-R S.465-5 (See Assumption #2)
Effective Power from Celestri NGSO into GSO (EPFD) 0.7 m antenna (4 degrees off axis)	-142.4 dB(w/m^2/1MHz)	-134.3 dB(w/m^2/1MHz)	

* Assumed Date Rate Bandwidth = BW = DR x 1.1365 (Block Coding) x 1/2 (QPSK) x 2/1 (FEC Coding).

TABLE 5

CELESTRI LINK BUDGET PERFORMANCE SUMMARY WORKSHEET

NGSO Satellite into 0.7 Meter GSO Antenna
1.2 Meter Antenna NGSO Earth Terminal at 51.84 Mbps
20 GHz Downlink

	Clear Sky	Rain Conditions	
Satellite Amplifier Power	1.4 w	8.7 w	Given transmitter power level before losses
Power	1.5 dBw	9.4 dBw	Arithmetic translation from power level to dBw
Transmitter Loss	-1.5 dB	-1.5 dB	Given Celestri satellite performance
Antenna Gain	32.8 dB	32.8 dB	Given Celestri satellite performance
EIRP (Power leaving the satellite)	32.8 dBw	40.7 dBw	Sum of power, losses and antenna gain
Atmosphere Loss	-1.2 dB	-1.2 dB	Clear sky atmospheric impact
Rain attenuation	0.0 dB	-7.1 dB	Impact of rain conditions
Pointing error	-1.2 dB	-1.2 dB	Assumed Polarization/Attitude Losses
Bandwidth conversion	-17.7 dB/MHz	-17.7 dB/MHz	Data Rate Bandwidth Ratio To 1 MHz*
Other unknown margin	-0.2 dB	-0.1 dB	Plug to get to Celestri number
Spreading loss for NGSO orbit	-139.5 dB/m^2	-139.5 dB/m^2	Translation into one sq. meter from NGSO Satellite to range of 2,660 Km
Power Flux Density (Power density at the ground)	-127.0 dB(w/m^2/1MHz)	-126.1 dB(w/m^2/1MHz)	Agrees with NGSO Celestri Appendix A
Impact on GSO Ground Terminal			
Rain attenuation add back	0	7.1 dB	No rain on GSO terminal
Pointing error add back	1.2dB	1.2 dB	No polarization/attitude impact at GSO terminal
Margin/unknowns add back	0.2 dB	0.1 dB	Factors not relevant to GSO
Off-axis advantage (4 degrees)	-20.3 dB	-20.3 dB	CyberStar™ 0.7m antenna on-axis gain = 40.6 with offset using 52 - 10 log (70/1.5) = 20.3 from ITU-R S.465-5 (See Assumption #2)
Effective Power from Celestri NGSO into GSO (EPFD) 0.7 m antenna (4 degrees off axis)	-145.9 dB(w/m^2/1MHz)	-138.0 dB(w/m^2/1MHz)	

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* Assumed Date Rate Bandwidth = BW = DR x 1.1365 (Block Coding) x 1/2 (QPSK) x 2/1 (FEC Coding).

TABLE 6

CELESTRI LINK BUDGET PERFORMANCE SUMMARY WORKSHEET

NGSO Satellite into 0.7 Meter GSO Antenna
1.8 Meter Antenna NGSO Earth Terminal at 155.52 Mbps
20 GHz Downlink

	Clear Sky	Rain Conditions	
Satellite Amplifier Power	1.0 w	5.0 w	Given transmitter power level before losses
Power	0.0 dBw	7.0 dBw	Arithmetic translation from power level to dBw
Transmitter Loss	-1.5 dB	-1.5 dB	Given Celestri satellite performance
Antenna Gain	37.4 dB	37.4 dB	Given Celestri satellite performance
EIRP (Power leaving the satellite)	35.9 dBw	42.9 dBw	Sum of power, losses and antenna gain
Atmosphere Loss	-1.2 dB	-1.2 dB	Clear sky atmospheric impact
Rain attenuation	0.0 dB	-5.7 dB	Impact of rain conditions
Pointing error	-1.1 dB	-1.1 dB	Assumed Polarization/Attitude Losses
Bandwidth conversion	-20.7 dB/MHz	-20.7 dB/MHz	Data Rate Bandwidth Ratio To 1 MHz*
Other unknown margin	-0.6 dB	-0.7 dB	Plug to get to Celestri number
Spreading loss for NGSO orbit	-140.2 dB/m^2	-140.2 dB/m^2	Translation into one sq. meter from NGSO Satellite to range of 2,900 Km
Power Flux Density (Power density at the ground)	-127.9 dB(w/m^2/1MHz)	-126.7 dB(w/m^2/1MHz)	Agrees with NGSO Celestri Appendix A
Impact on GSO Ground Terminal			
Rain attenuation add back	0	5.7 dB	No rain on GSO terminal
Pointing error add back	1.1dB	1.1 dB	No polarization/attitude impact at GSO terminal
Margin/unknowns add back	0.6 dB	0.7 dB	Factors not relevant to GSO
Off-axis advantage (4 degrees)	-20.3 dB	-20.3 dB	CyberStar 0.7m antenna on-axis gain = 40.6 with offset using 52 - 10 log (70/1.5) = 20.3 from ITU-R S.465-5 (See Assumption #2)
Effective Power from Celestri NGSO into GSO (EPFD) 0.7 m antenna (4 degrees off axis)	-146.5 dB(w/m^2/1MHz)	-139.5 dB(w/m^2/1MHz)	

* Assumed Date Rate Bandwidth = BW = DR x 1.1365 (Block Coding) x 1/3 (8PSK) x 2/1 (FEC Coding).

APPENDIX B

INITIAL LIST OF ADDITIONAL INFORMATION REQUIRED TO EVALUATE CELESTRI PROPOSAL

The following information must be provided, and the following questions must be adequately addressed, to permit GSO system operators to develop a meaningful initial evaluation of the Motorola Celestri proposal:[1]

I. EPFD INTERFERENCE SIMULATION SOFTWARE

1. Motorola should identify and provide the specific version of the simulation software package used or state how it can be obtained by others.

2. Motorola should disclose all inputs made to the software (including variables, assumptions, mathematical formulas, and all customizations) that produced the output used in its application.

3. If Motorola has used proprietary simulation software (or a proprietary version or modification of software) that is not available to others it should provide comprehensive, detailed technical information about the software as well as reasonable access to that software by the FCC and other interested parties for independent analysis.

4. Motorola must provide any sensitivity studies that have been performed on the underlying simulation assumptions or input parameters. For example, Motorola must provide sensitivity of EPFD to the location of the victim antenna, the sensitivity to the chosen simulation time-step size and simulation elapsed time, and the sensitivity to variations to the NGSO satellite constellation orbital parameters (for variations within Celestri specifications).

5. Motorola must provide a complete description of:

   (i) the mathematical algorithms used in connection with the simulated interference calculations, and their derivations, that are used in the simulations. These should include the algorithms used for: (i) making the interference calculations; (ii) simulating the orbital geometry; and (iii) the systems components such as, but not limited to, the dynamic NGSO satellite iso-flux antenna characteristics;

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1 Although Celestri's application and subsequent amendment begin to address some of the information requested below, the information provided is not sufficient and lacks detail.

(ii) all required and optional input information needed to run the simulation, as well as a description of all output information available from the simulation;

(iii) how rain attenuation, polarization, and power control are considered and handled in the simulation;

(iv) the modulation methods such as spreading or non-spreading techniques that are implemented in the simulation;

(v) how NGSO diversity operation is simulated;

(vi) how interference to and from inclined GSO satellite networks is addressed in the simulation;

(vii) how multiple NGSO systems are accounted for and simulated. Results from simulations that show the statistical PFD effects of increasing numbers of NGSO networks also should be provided; and;

(viii) any other features and assumptions incorporated in the simulation software.

6. Motorola must disclose the method used that would allow a GSO system operator to identify a NGSO source of interference.

II. NGSO SYSTEM OPERATION INTEGRITY

7. Motorola must disclose the protection methods used to prevent contamination of transmission in the direction of the victim antenna when the NGSO satellite enters the exclusion zone in the instance of normal operational failure.

8. Motorola must reveal how GSO system operators and Motorola will monitor, during actual operation, Celestri system performance of the sharing criteria now being developed.

9. Motorola must disclose the method which the Celestri system will use to prevent simultaneous NGSO earth terminal transmission on the same carrier frequency.

10. Motorola must disclose the method used to protect erroneous transmissions by NGSO earth stations when using uplink power control.

III. CHARACTERISTICS OF EPFD PARAMETER

11. Motorola must provide more detailed information on the characteristics of short term interference events, particularly the duration statistics as a function

of victim antenna beamwidth (*e.g.,* average length, maximum length, duration probability distribution, and EPFD level probability distribution).

12. Motorola must explain whether its simulation takes into account the signals arriving at a GSO earth terminal, including those signals generated from the NGSO co-frequency beams that are arriving from the sidelobes of the NGSO co-frequency beams at the main beam of GSO antennas whose size will vary from 0.7 to 5.5 m antennas.

13. Motorola must provide more precise description of spacecraft antenna beam patterns, overlap of beams and coverage; Specifically, how are the 260 transmit and the 432 receive beams arranged and what are their sidelobe characteristics?

14. Motorola must describe how the two separate Celestri bands, namely the NGSO and the GSO bands, are subdivided into the 7 sub-band frequency reuse. Are the NGSO bands subdivided into 7 sub-bands and the GSO similarly subdivided into 7 sub-bands separately or are they integrated?

15. Motorola must indicate if, when the NGSO satellite enters the exclusion zone of ±4 degrees whether individual carriers are turned off or is the entire GSO band turned off.

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing comments was sent by first-class mail, postage prepaid, this 22nd day of December, 1997, to each of the following:

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