V. INTERFERENCE AND SHARING ANALYSIS

Set forth below, and in Appendix B, are the interference and sharing considerations under current ITU and U.S. allocations in the 18.8-19.3 GHz, 19.7-20.2 GHz, 28.6-29.1 GHz, and 29.5-30.0 GHz bands (Ka-band) that apply to the proposed Celestri LEO System.

A. ITU And U.S. Allocations

1. ITU Ka-Band Allocations

In Tables V-1 and V-2, the shaded areas denote the ITU frequency allocations associated with various types of service.

Table V-1: ITU 18 GHz Band Allocation

Service Type	17.7 - 17.8	17.8 - 18.1	18.1 - 18.6	18.6 - 18.8	18.8 - 18.9	18.9 - 19.3	19.3 - 19.7	19.7 - 20.1	20.1 - 20.2
FSS									
Res. 46 for FSS*					To be considered at WRC-97	May be re-considered at WRC-97			
MSS								Region 2 primary	
BSS	Region 2 only								
Fixed Service									
Mobile Service	Region 2 secondary			Except aero					
Earth Exploration Satellite (passive)				Region 2 primary					
Space Research (passive)				Region 2 primary					

Primary Allocation: **Secondary Allocation:**

* Resolution 46 (WRC-95) allows non-geostationary FSS to be co-primary with geostationary FSS. The ITU has made Radio Regulation 2613 inapplicable where Resolution 46 is applicable

Table V-2: ITU 28 GHz Band Allocation

Service Type	27.5 - 28.5	28.5 - 28.6	28.6 - 28.7	28.7 - 29.1	29.1 - 29.4	29.4 - 29.5	29.5 - 29.9	29.9 - 30.0
FSS								
Res. 46 for FSS			To be considered at WRC-97	May be re-considered at WRC-97				
MSS							Region 2 primary	
Fixed Service								
Mobile Service								
Earth Exploration Satellite								

Primary Allocation: **Secondary Allocation:**

2. U.S. Ka-Band Plan

The U.S. Ka-band designations for the spectrum are set forth in Tables V-3 and V-4, below.[1]

Table V-3: U.S. 18 GHz Band Plan

Service Type	17.7 - 18.8	18.8 - 19.3	19.3 - 19.7	19.7 - 20.2
NGSO/FSS				
GSO/FSS				
Fixed Service				
MSS Feeder Links				

Primary Allocation: **Secondary Allocation:**

[1] See 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 Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, FCC 96-311, CC Dkt. No. 92-257 (July 22, 1996) (First Report and Fourth Notice of Proposed Rulemaking).

Table V-4: U.S. 28 GHz Band Plan

Service Type	27.5 - 28.35	28.35 - 28.6	28.6 - 29.1	29.1 - 29.25	29.25 - 29.5	29.5 - 30.0
NGSO/FSS						
GSO/FSS						
LMDS						
MSS Feeder Links						

Primary Allocation: **Secondary Allocation:**

B. Celestri LEO System Band Plan

The Celestri LEO System will operate as a global, NGSO system in the Fixed-Satellite Service (NGSO/FSS). The space-to-Earth service links will operate in the 18.8-19.3 GHz and 19.7-20.2 GHz bands and the Earth-to-space service links will operate in the 28.6-29.1 GHz and 29.5-30.0 GHz bands.

C. Interference and Sharing Analysis

The analysis shown in Appendix B addresses the potential for harmful interference between the Celestri LEO System and other systems and services. The analysis shows that the Celestri LEO System can share the same bands on a co-frequency, co-coverage basis with other primary and secondary systems and services. It further shows that it is possible for multiple NGSO/FSS systems to share the same service link bands.

1. Interference and Sharing with Other NGSO Systems

Mutual harmful interference between NGSO systems using overlapping spectrum is avoidable with the use of joint mitigation techniques. The frequency of occurrence and duration of interference events between NGSO systems sharing the same spectrum are a function of the technical parameters of the systems. One approach for mitigating interference events is satellite diversity,

which relies on the availability of alternative satellites to provide a particular radio link. Because the Celestri LEO System constellation has been designed so that multiple satellites are in view at any specified Earth location a large percentage of the time, space diversity can be used to share spectrum with other NGSO systems.

A sharing analysis has been completed that evaluates the potential for sharing between the direct-to-home terminals of the Celestri LEO System and the standard terminals of the recently licensed Teledesic NGSO system[2] when satellite diversity is employed. This analysis is included in Appendix B. It shows that the two systems can share the available spectrum by employing satellite diversity mitigation techniques. The Celestri LEO System constellation has been designed to provide double coverage 90% of the time for Earth Latitudes below 60° and more than 99% of the time for Latitudes between 18° and 48°. Thus, by using space diversity, an earth terminal can be assigned to another serving satellite to assure virtually seamless service.

Space diversity incurs a cost in terms of increased system complexity and reduction in system throughput. If both NGSO systems incorporate mitigation techniques such as power control, space diversity and sidelobe control, co-frequency sharing becomes much easier to accomplish.

The potential for sharing with a third NGSO system is a greater challenge because the space capacity available to mitigate interference may be completely allocated for sharing with the other NGSO system. If other NGSO systems were to include provisions for sharing in the design of their systems, however, more than two NSGO systems could use the same spectrum.

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[2] See Teledesic Order, 12 FCC Rcd. 3154 (1997)

While sharing the NGSO portions of the Ka-band can be achieved technically, the operators of the Teledesic network and Celestri LEO System will have to cooperate in the development and implementation of the necessary mitigation techniques if sharing is to work. This will require a joint commitment to make the necessary system changes and to coordinate operational parameters in an equitable fashion.[3]

2. Interference and Sharing with GSO Systems

Recently, the Commission authorized 73 GSO satellites in the 20/30 GHz band, with spacing of 2° or more in the orbital arc ranging from 147° West Longitude to 175.25° East Longitude.[4] In the U.S., these GSO systems are secondary to NGSO systems in the 18.8-19.3 GHz and 28.6-29.1 GHz bands; however, NGSO systems are secondary to GSO systems in the 19.7-20.2 GHz and 29.5-30.0 GHz bands. In the rest of the world, the GSO and NGSO systems are co-primary in these bands.

Mutual interference between NGSO and GSO systems is considered unavoidable if mitigation techniques are not applied. Satellite diversity is even more effective for NGSO-GSO sharing because the portion of the sky where mitigation is required is always fixed relative to any given earth station. There simply are fewer "moving targets" to include in the joint integration implementation. However, satellite diversity as a solution will be limited to the extent that sharing with other NGSO systems is required. Appendix B sets forth this sharing analysis.

The World Radio Conference (WRC-97) Preparatory Meeting (CPM-97) Report identifies interference mitigation techniques to improve sharing

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[3] See Teledesic Order, at paras. 28-29.

[4] See Assignment of Orbital Locations to Space Stations in the Ka-Band, DA 97-967 (Int'l Bureau, May 9, 1997).

possibilities between GSO FSS and NGSO FSS networks.[5] The following techniques which may reduce the interference between networks operating in the Ka-band are proposed:

1. Satellite diversity;
2. Restricted operational elevation angles;
3. High gain antennas;
4. Adaptive power control;
5. Signal design and network traffic management;
6. GSO arc avoidance;
7. Optimization of the constellation;
8. Satellite footprint shift;
9. Geographical isolation of earth stations;
10. Site diversity;
11. Exclusion zone;
12. Hybrid systems;
13. Residual interference limitation.

The Celestri LEO System will employ mitigation techniques 1 through 7 to enable sharing with GSO/FSS systems.

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[5] CPM Report at Section 4.4.1.1.3.

3. Interference and Sharing with Fixed Services

a. Celestri LEO System Downlink Frequency Band

The Celestri LEO System service downlinks are not expected to cause harmful interference into the Fixed Service ("FS") since they will meet the power flux density limits of Section 25.208(c) of the Commission's Rules and ITU RR S21.16 (Article S21). See Tables IV-4 and IV-5 and Appendices A and B.

The Celestri LEO System earth stations may experience interference from FS in the bands. The only band where this is applicable is 18.8-19.3 GHz in both the U.S. and other parts of the world. In the case where terrestrial microwave stations are located near the low data rate CPE terminals for the Celestri Architecture (e.g., direct-to-home and small business terminals), it may not be practical to coordinate with the FS stations. In this case, interference will be mitigated from the FS stations into the Celestri LEO System low data rate terminals through the use of shielding and other techniques. It is expected that the larger, higher-data-rate terminals in the Celestri LEO System will be coordinated using rules similar to those commonly employed in other co-primary FS and FSS bands.

b. Celestri LEO System Uplink Frequency Band

In the U.S., there are no FS allocations in the Celestri LEO System uplink bands. In other parts of the world where FS is allocated in the uplink bands, interference will be mitigated through coordination, if required. Most likely, such coordination will not be required since the Celestri LEO System will operate at a minimum elevation angle of 16 degrees and will meet the EIRP limits on the horizon. Moreover, the geographic area requiring actual mitigation for each FS installation will be much smaller than the minimum coordination area prescribed in ITU-R Document Rec. IS.847-1.

4. Interference with Mobile Satellite Services and Mobile Services

Due to the ubiquitous nature and mobility of Mobile Service and MSS terminals, it is not expected that sharing is possible with NGSO/FSS systems.

VI. ADVANCE PUBLICATION AND ITU COORDINATION

Motorola is submitting in Appendix C all of the information required to advance publish the Celestri LEO System with the ITU. Motorola respectfully requests that the Commission forward this information to the ITU for publication, subject to any applicable constraints on the timing of such submissions regarding a portion of the spectrum requested for the system. See WRC-95, Resolution PLEN-1.

VII. COMPLIANCE WITH INTELSAT ARTICLE XIV OBLIGATIONS

Motorola recognizes that Article XIV(d) of the INTELSAT Agreement imposes certain consultation requirements on the United States.[6] To the extent this provision is applicable to the Celestri LEO System, Motorola understands that the requested license could be conditioned on the completion of any necessary consultations.

With respect to the economic component of Article XIV(d) consultations, the INTELSAT Assembly of Parties has now determined that a separate satellite system is presumed not to cause economic harm to INTELSAT, regardless of

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[6] Agreement Relating to the International Telecommunications Satellite Organization, Aug. 20, 1971, Art. XIV(d), 23 U.S.T. 3813, T.I.A.S. No. 7532, 10 I.L.M. 909 (1971).

the number of circuits provided by such a system.[7] With respect to the technical component of Article XIV(d) consultations, Motorola assures the Commission that it will provide all information necessary when the consultation process is initiated.

VIII. LEGAL QUALIFICATIONS

Motorola is legally qualified to hold the requested license for the Celestri LEO System. The Commission recently passed upon the qualifications of Motorola, Inc. when it awarded Motorola Satellite Communications, Inc., also a wholly-owned subsidiary of Motorola, Inc., a license to construct, launch and operate the IRIDIUM® System.[8] Appendix E hereto contains an up-to-date FCC Form 430 reflecting all of the information required to find Motorola legally qualified to hold the requested license.

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[7] Report of the Twenty-First Session of the INTELSAT Assembly of Parties, INTELSAT Doc. AP-21-3E FINAL PV/4/97, at 4-5.

[8] Motorola Satellite Communications, Inc., Order and Authorization, 10 FCC Rcd. 2268 (1995), recon. denied FCC 96-279 (1996). See also Application of Comm, Inc. to Construct, Launch, and Operate a Ka-Band Satellite System in the Fixed-Satellite Service, Order and Authorization, DA 97-968 (Int'l. Bureau, May 9, 1997).

IX. FINANCIAL QUALIFICATIONS

A. Milestone Schedule

1. Contract Milestones

Table IX-1 sets forth the Celestri Multimedia LEO System contractual milestones:

Table IX-1: Contract Milestones

Contractual Milestones	Year After Authorization
Spacecraft RFP issued	N/A
Spacecraft contractor selected	N/A
Spacecraft contract executed	1
Launch services contract executed	2
Financing completed	N/A

The financing for the Celestri Multimedia LEO System will be secured from a combination of internal Motorola funds and other potential external sources. As discussed in Section C, below, Motorola satisfies the financial qualification standards set forth in Part 25 of the Rules. See 47 C.F.R. § 25.140.

2. Spacecraft Milestones

Table IX-2 sets forth the Celestri LEO System spacecraft milestones:

Table IX-2: Spacecraft Milestones

Celestri LEO System Spacecraft Milestones	Months After Authorization
Satellite construction begins	6 Months
First satellite constructed	39 Months
First satellite launched	40 Months
Last satellite constructed	50 Months
Last satellite launched	51 Months
Full operational service	54 Months

B. Projected System Costs

The investment required for the Celestri Multimedia LEO System includes the cost to develop and construct satellites, the associated launch services and launch insurance costs, satellite system control costs, network management hardware costs, software development costs, and other pre-operating expenses. Motorola intends to sub-contract appropriate portions of the research and development effort as well as selected segments of the satellite constellation and ground infrastructure construction activities. In addition to the construction costs, the investment costs include the operating expenses through the first year of operations, commencing when the first satellites are launched. Operating costs include service delivery expenses, maintenance expenses, and finance, marketing and other various administrative expenses, but exclude depreciation. Annual operating costs are adjusted by an inflation factor.

The costs projected herein are based primarily on stand-alone development and deployment activities for the Celestri LEO System. In fact,

however, Motorola expects the cost of the system to be substantially less than this stand-alone estimate: the joint development of the Celestri Multimedia LEO System described in this Application and Motorola's proposed GSO (Millennium) and LEO (M-Star) Systems will allow substantial synergies and cost savings. Indeed, the $12.9 billion cost estimate already includes the estimated cost of constructing and launching the first of the four satellites of the Millennium System.

End-user terminal equipment is not part of this filing and is not included in the total projected system cost. All necessary subscriber equipment will be purchased by end users.

Table IX-3 shows that the estimated construction and launch costs for the entire system, plus operating expenses (excluding depreciation) through Year 5 (the first year of operation for the system) amount to $12.9 billion.

Table IX-3: Projected System Cost ($ Millions)

	Pre-Auth	Year 1	Year 2	Year 3	Year 4	Year 5
Construction Launch and Launch Insurance Costs	30	960	2,750	4,300	4,300	300
Operations and Maintenance	0	5	5	10	50	190
Annual Totals	30	965	2,755	4,310	4,350	490
Cumulative Total	30	995	3,750	8,060	12,410	**12,900**

C. Projected Revenues

Motorola's estimate of the revenue stream from the Celestri LEO System is illustrated in Table IX-4.

Table IX-4: Projected Revenues ($ Millions)

	Years after Full Operation							
	1-4	**5**	**6**	**7**	**8**	**9**	**10**	**Total Revenues**
Revenues	0	5,300	13,000	17,900	17,900	17,900	17,900	89,900

The consolidated revenue projections for the Celestri LEO System are sufficient to recover all of the estimated operating expenses over the life of this project. Moreover, these projections represent a rate of return that sufficiently compensates Motorola for the risk associated with this proposed telecommunications venture.

D. Financial Qualifications

Motorola, a wholly-owned subsidiary of Motorola, Inc., has the current financial ability to meet the estimated costs of construction and launch of the proposed system, as well as the estimated expense of operating the entire system for one year after launch. The 1996 audited Consolidated Balance Sheet and Statement of Consolidated Earnings of Motorola, Inc., the applicant's sole corporate parent, are set forth in Appendix D. A declaration signed by Mr. Bary Bertiger, Corporate Vice President of Motorola, Inc., verifies the financial information set forth in the consolidated financial statements. These statements show that Motorola's current assets as of December 31, 1996 amounted to $11,319 billion and its earnings before income taxes for 1996 were $1.775 billion -- a total of $13.094 billion in current assets and operating income -- and thus exceed the $12.9 billion estimated costs of construction, launch, and first-year operating expenses for the entire system.

X. TECHNICAL QUALIFICATIONS

A. System Coverage

The Celestri LEO System is designed to provide high capacity data services between 60° South and 60° North Latitude at elevation angles above 16°. Service can be extended to 70° North and South Latitude by mitigating the effects of low elevation angles. For Latitudes between 18° and 48°, which includes all of the continental U.S. and most of the population centers of Europe and Asia, coverage of all locations by at least two satellites is provided 99% of the time. Three satellites are in view of subscribers within these latitudes more than half of the time.

B. Service in the United States

The Celestri LEO System is designed to provide continuous service to all 50 States of the United States, Puerto Rico, and the U.S. Virgin Islands. Users above 60° North Latitude will require larger antennas to mitigate the effects of low elevation angles.

C. Bandwidth Utilization

The Celestri LEO System satisfies the intent of Section 25.210 of the Commission's Rules by fully utilizing its requested bandwidth and operating in a manner that maximizes spectrum efficiency. Phased array antennas aboard each satellite are used to project relatively narrow beam patterns, which create small cells on the Earth's surface. This design permits efficient reuse of the spectrum, as indicated by a capacity density nearly 9 times greater than proposed GSO Ka-band systems in areas of high demand. Indeed, the same frequency bands can be simultaneously reused in approximately 680 locations over the land areas of the system's global coverage. The spectrum in each reuse area can be allocated to provide high peak capacity where and when needed.

XI. REQUEST FOR WAIVER OF THE COMMISSION'S RULES

Motorola requests that the Commission grant a limited waiver of Section 25.210 of the Commission's Rules. See 47 C.F.R. § 25.210. The Celestri LEO System satisfies the intent of Section 25.210 by using the required bandwidth in the uplink and downlink bands in a manner that maximizes system capacity. The LEO design is inherently incapable of satisfying the explicit requirements of Section 25.210, which was intended to apply to geostationary orbit satellites. Pending a modification of this Rule to meet the design needs of LEO systems, Motorola requests a waiver of Section 25.210 to the extent necessary.

XII. WAIVER PURSUANT TO SECTION 304 OF THE ACT

In accordance with Section 304 of the Communications Act of 1934, as amended, 47 U.S.C. § 304, Motorola hereby waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise.