BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, DC 20544

In the Matter of	)	
	)	
Lockheed Martin Corporation	)	File No. SAT-LOA-_____
	)	
Application for Authority to Construct, Deploy, and Operate the Parsec™ Lunar Communications System	)	Call Sign _____

Application of Lockheed Martin Corporation

Lockheed Martin Corporation ("Lockheed Martin") hereby requests authority under Section 25.114 of the Federal Communications Commission's ("Commission") rules to construct, deploy, and operate a lunar communications system branded "Parsec™" using spectrum in the S-, X-, and Ka-band frequencies for a 15-year license term.[1] Lockheed Martin also seeks a waiver to operate in S- and X-band frequencies omitting a non-federal allocation and to provide certain communications using Ka-band.

No U.S. commercial options exist for multi-use lunar communications or data storage. To address this need, Parsec will provide a commercial lunar communications relay service initially for NASA and others with commercial lunar far side and south polar region missions. The services are critical to the advancement of U.S. commercial, government, and scientific interests and will further U.S. space policy objectives. As a result, grant of this license would strongly serve the public interest because Parsec is essential to the advancement of lunar exploration, scientific research, and the lunar economy.

1. BACKGROUND

Lockheed Martin is developing a cislunar communications system that is projected to provide service on a commercial subscription basis by early 2024. For initial service, two lunar communications relay spacecraft will operate in lunar orbit; each spacecraft will be based on Lockheed Martin's Deep Space Exploration platform. Through this application, Lockheed Martin seeks authority to construct, deploy, and operate the first two Parsec relay spacecraft. Lockheed Martin understands and accepts the risks of initiating construction of the spacecraft before receiving a grant of authority from the FCC.

[1] *See* 47 C.F.R. § 25.114.

2. GENERAL DESCRIPTION OF SYSTEM FACILITIES, OPERATIONS, AND SERVICES

Parsec will provide cislunar communications relay and data services for missions on the lunar surface and in lunar orbit. Parsec has been designed to be compatible with NASA's LunaNet initiative for an internet-like architecture to support lunar missions.[2] The LunaNet system requirements are intended to promote maximum interoperability and to enable use by a broad range of operators. Lockheed Martin is requesting specific spectrum to be consistent with the LunaNet standards. NASA has encouraged the commercial development of cislunar communications systems to enable it to procure such services commercially rather than committing budget to service-providing assets.[3]

Parsec will enable communications to and from Earth (Earth station) for lunar assets (service user) through its Parsec lunar orbiting relay satellites (space stations). Parsec enables surface-to-surface communications through the satellite relay link for surface assets. Parsec will also use communications links, coupled with radiometric navigation techniques, to provide location, velocity, and time information to assets on the lunar surface and in lunar orbit.

Specifically, Parsec will provide service by establishing a communications link with a customer's lunar mission, either in orbit or on the lunar surface. Parsec will either use this link to relay customer data to and from Earth or relay that data to another point on the lunar surface. Parsec provides real-time relay capabilities when both ends of the link (Moon and Earth) are visible. When one end of the link is not available, Parsec provides store-and-forward capabilities for customer data; data can be stored onboard the Parsec vehicle until the necessary link is available. Customers are also able to host applications onboard Parsec vehicles to process and manipulate their data.

The communication link between Parsec and a lunar user can also be used to obtain position, velocity, and time information. Parsec will calculate doppler and range during communication with a lunar user over the allocated frequencies and combine this information with Parsec's orbit knowledge to calculate an absolute position for a lunar user in orbit or on the surface. For orbiting vehicles, this method can also calculate velocity.

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[2] *See* David Israel et al., LunaNet: a Flexible and Extensible Lunar Exploration Communications and Navigation Infrastructure and the Inclusion of SmallSat Platforms, Presentation and Paper before Technical Session XII: Communications at Utah State University Small Satellite Conference, SSC20-XII-03, at Table 1 (2020), https://bit.ly/3LCI3n0.

[3] *See generally id*.

The complete system architecture appears in Figure 1.

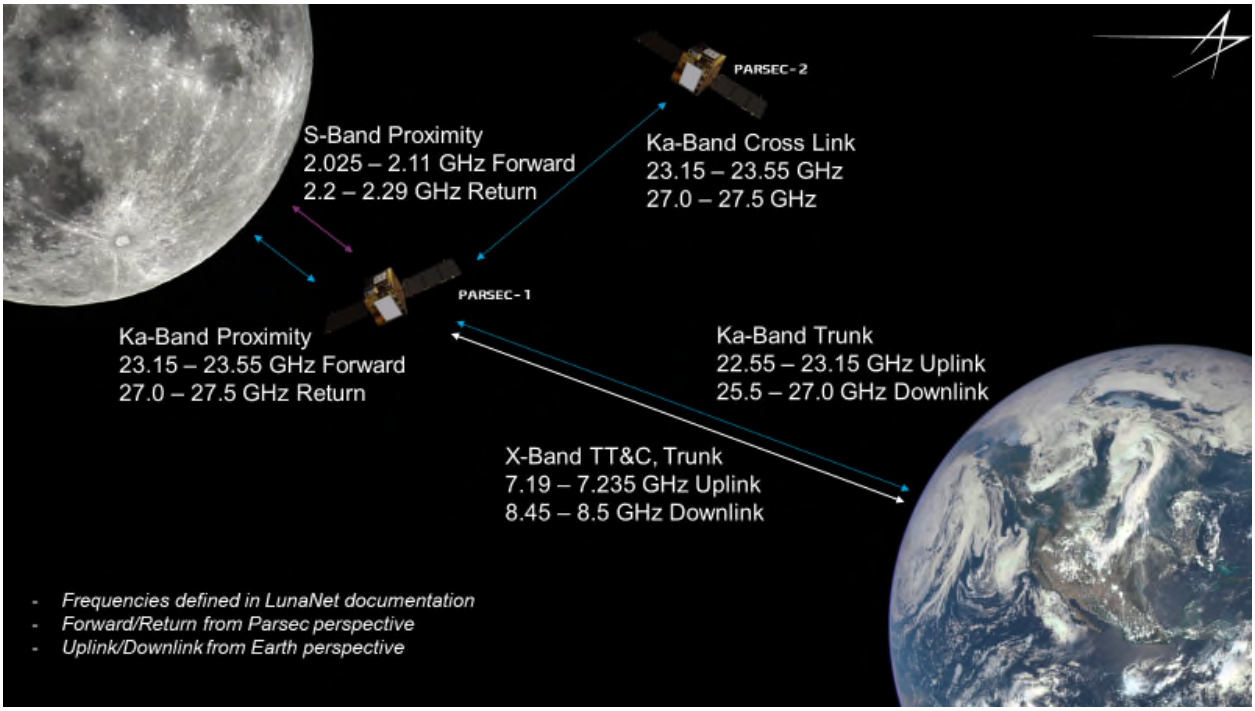

Figure 1: Parsec Architecture

Parsec comprises three RF link types.

1. Earth links represent a communications link between an Earth-based ground station and the Parsec relay satellite(s) orbiting the Moon. This link will use the specified Ka-band and X-band frequency ranges. Ka-band will support uplink and downlink of high-rate mission data. X-band will support low-rate telemetry, tracking, and control operations and act as a backup for low-rate mission data uplink and downlinks.
2. Proximity links represent a communications link between the Parsec relay satellite(s) and users of Parsec serving the Moon or assets located on the lunar surface. This link will use the specified Ka-band and S-band frequency ranges. Ka-band will be used for forward and return links with high-rate mission data. S-band will support low-rate mission data and spacecraft hailing operations in both directions. Both S-band and Ka-band will support ranging and timing operations between the Parsec relay and surface users.
3. Cross links represent a communications link between the Parsec relay satellite(s) and other lunar-orbiting satellites and spacecraft. Ka-band will support mission data relay/transmission, such as critical crew communications and real time high-definition video and support, along with ranging and timing operations between the Parsec relay and other lunar-orbiting satellites and spacecraft.

Given these capabilities, the system constitutes a space research service and inter-satellite service.

Space research service. The space research service covers spacecraft that participate in "scientific or technological research purposes."[4] To enable lunar exploration, experiments, and communications for crewed scientific missions, Parsec will enable communications to and from Earth (Earth stations) for lunar assets[5] (service user) through Parsec's lunar orbiting relay satellites (space stations). As a result, Parsec qualifies as a space research service.

Inter-satellite service. The inter-satellite service provides links between satellites.[6] Parsec will enable surface-to-surface communications through the satellite relay link for lunar surface assets and provide location-and-time information to assets on the lunar surface. As a result, Parsec's communications between satellites qualifies as an inter-satellite service, and we seek a waiver to provide communications between Parsec and stations on the lunar surface.

Because the proposed space research service and inter-satellite service frequencies host shared federal and non-federal allocations, Lockheed Martin has started coordinating its spectrum use and will complete the process, as necessary, before the Commission authorizes Parsec.[7]

[4] *See* ITU RR No. 1.55.
[5] Lunar assets might include celestial rovers, crewed spacecraft, imagers, and/or other space exploration payloads.
[6] *See* ITU RR No. 1.22.
[7] *See generally* 47 C.F.R. § 2.106.

Table 1 specifies the requested frequencies, radio communication services, and link direction for the following non-federal allocated bands.

Band	Frequency (GHz)	Service	Link Direction
S-band	2.025-2.11	Space Research	space-to-space (Parsec transmitting)
X-band	8.45-8.5	Space Research	space-to-Earth
Ka-band	22.55-23.15	Space Research	Earth-to-space
	25.5-27.0[8]	Space Research	space-to-Earth
	23.15-23.55	Inter-Satellite	space-to-space (including Parsec transmitting to stations serving lunar surface)
	27.0-27.5	Inter-Satellite	space-to-space (including Parsec receiving from stations serving lunar surface)

Table 1: Parsec Non-Federal Frequency Plan

[8] Although the 25.5-27.0 GHz band has received consideration for future upper microwave flexible use service ("UMFUS") deployment, no formal service allocation or related rule adoption has occurred. *See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services et al.*, Third Further Notice of Proposed Rulemaking et al., 33 FCC Rcd 5576 ¶¶ 79-92 (2018). Should UMFUS enter the band, however, Lockheed Martin requests that any Parsec U.S. earth station hold grandfathered status, including the right to operate under the terms of their existing authorizations without taking into account possible interference to UMFUS operations. *See, e.g.*, *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services et al.*, Report and Order et al., 31 FCC Rcd 8014 ¶ 59 (2016) (establishing grandfathered status for certain earth stations with respect to UMFUS deployments).

Table 2 specifies the requested frequencies, radio communication services, and link direction for the following federal allocated bands.

Band	Frequency (GHz)	Service	Link Direction
S-band	2.2-2.29	Space Research	space-to-space (Parsec receiving)
X-band	7.19-7.235[9]	Space Research	Earth-to-space

Table 2: Parsec Federal Frequency Plan

As discussed in section 9, Lockheed Martin seeks a waiver to use this spectrum unallocated to non-federal use to stay within the operational bounds prescribed by NASA in its LunaNet frequency plan. In addition, as discussed in section 9, Lockheed Martin seeks a waiver to use the 23.15-23.55 GHz and 27.0-27.5 GHz bands in communications between Parsec and stations on the Lunar surface.

3. CUSTOMERS AND BUSINESS PLAN

Currently, each industry lunar mission develops and pays for a single-use, custom solution for hardware, frequency spectrum, regulatory approvals, Earth station networks, testing, and operations. In addition, today's missions have limited capability for onboard data storage and processing, with the bulk of the processing done on Earth. Parsec will use standard interfaces to enable missions to buy commercial communications, data storage, and analytics services. These services will enable missions to perform local storage and processing to avoid the increased light-time delay between the Moon and Earth.

In particular, Parsec will provide a communications link for any customer to support a full mission. This communications link will connect the lunar surface asset back to Earth through the Parsec relay spacecraft as well as connecting one surface asset to another. The user of the Parsec service will connect into the network with their surface communications transceiver to establish the RF link with the Parsec relay spacecraft. The user will then receive spacecraft data on the ground, which is transmitted to its mission operations center. The Parsec service will carry the transmission from lunar orbit back to Earth, transmissions from Earth stations back to the user, and any on-board data processing where requested. Through the established communications link, the user will send and receive spacecraft commands to perform vital mission operations

[9] Lockheed Martin recognizes footnote G134 of the U.S. Table of Frequency Allocations and that any authority to operate Parsec in the band must ensure protection of the Department of Commerce Geostationary Operational Environmental Satellites system. Lockheed Martin accepts that coordination with the Department of Commerce will need to be completed prior to operation in the band.

and send payload and instrument data back to Earth. This service will reduce the steps required by the user and provide a single interface.

Lockheed Martin anticipates that the first Parsec mission will provide services primarily to NASA. The business will expand to include other U.S. entities (commercial, educational, governmental, and research), international space agencies, and other governments. Various international space agencies and governments as well as commercial entities have expressed a need for the services Parsec will provide. Commercial customers could include commercial lunar lander companies, commercial rover companies, and scientific institutions.

4. MISSION DESCRIPTION

The spacecraft launch, transit, and orbit information follow.

Launch. The first Parsec launch is anticipated to occur in late 2023 to support NASA Commercial Lunar Payload Services missions requiring connectivity for near side, far side, and south pole missions in 2024. Launch will be from the Cape Canaveral launch facility on either a dedicated small launch vehicle or rideshare on a large launch vehicle. Lockheed Martin expects that it will launch the second Parsec spacecraft in 2025; however, the actual launch date might vary depending on business needs.

Transit. The launch vehicle will place the spacecraft in a trans-lunar injection ("TLI") orbit. The spacecraft will perform a transfer maneuver from TLI to insertion into final lunar orbit. The details of these two phases will depend on the specific launch vehicle chosen. From launch to TLI should take roughly 15 minutes. The vehicle will spend roughly 4.5 days on the lunar transfer trajectory before inserting into the vehicle's final lunar orbit. From launch to final orbit will take roughly 5 days.

Lunar Orbit. To optimize coverage of lunar assets and connectivity to Earth stations while finalizing customer and launch-provider needs, the operational orbits of each spacecraft may need to change slightly. Table 3 shows there will be three distinct orbits for various phases of the mission, ranging in inclination from 56.2 to 60.5 degrees and in period from 12 to 13.2 hours, and Figure 2 below depicts one possible orbital configuration. As discussed in section 9, Lockheed Martin seeks a waiver to the extent necessary for operational authority in an orbital range (instead of specific orbital parameters) consistent with other previously authorized non-geostationary orbit ("NGSO") missions.

Number of orbital planes	2
Number of space stations in each plane	2
Inclination of the orbital plane(s)	56.2° - 60.5°
Orbital period	43200 - 47520 seconds
Apogee (apolune)	9,828 - 10,466 km
Perigee (perilune)	2,458 - 2,616 km
Argument(s) of perigee	90°
Active service arc(s)	-56.2° to 56.2° (The two spacecraft in phase will service assets on the lunar surface for the entire duration of the orbit.)
Right ascension of the ascending node(s)	0°
For each satellite in each orbital plane, the initial phase angle at the reference time	The first satellite will insert into the defined orbit around October 17, 2023, corresponding to a true anomaly of 0 degrees.

Table 3: Parsec Projected Orbital Parameters

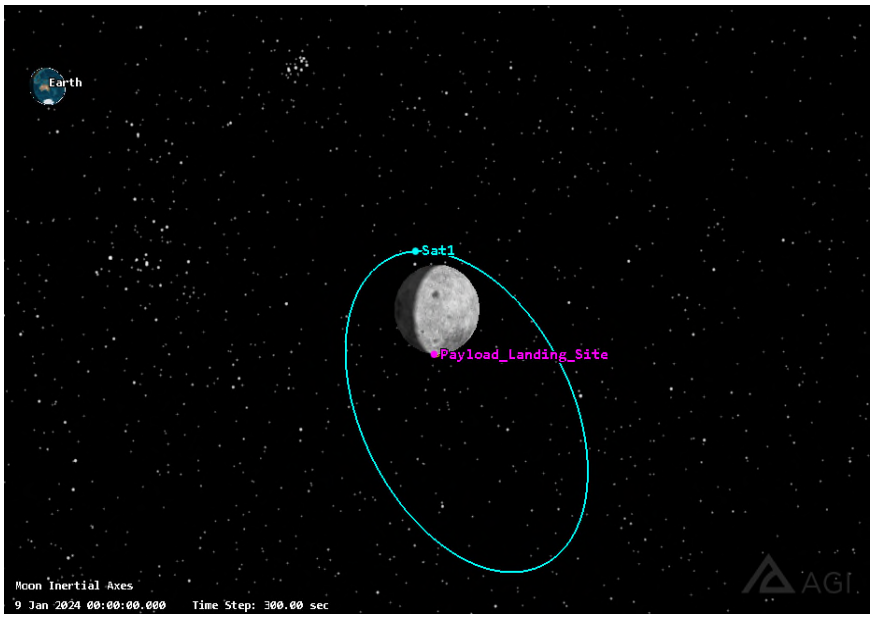

Figure 2: Sample Lunar Orbit Depiction

5. PAYLOAD AND BUS DESCRIPTION

The Parsec spacecraft bus will be a Lockheed Martin Deep Space common platform with flight heritage derived from multiple NASA missions. The spacecraft will be a smallsat that is compatible with an ESPA-Grande launch volume. It will weigh less than 200kg and carry all major spacecraft subsystems including propulsion, power from solar arrays and batteries, structure, avionics, guidance navigation and control, telecommunications, and flight software. The vehicle's design lifetime is 4 years, but based on past experience, Lockheed Martin expects it to continue beyond its design life. Lockheed Martin also expects to refresh spacecraft as needed, replacing them with substantially similar spacecraft.

The Parsec bus will carry a variety of payloads for various mission needs. The primary payload consists of an RF-based communication system capable of operating at S-, X-, and Ka-band frequencies with software-defined radios and a dedicated payload processor.[10]

- Facing Earth, the payload will have two medium gain patch antennas operating at X-band for low-data rate telemetry, tracking, and command and data backup, along with a high-gain directed antenna operating at Ka-band for high-rate Earth-to-Moon communications (trunk link).
- Facing the Moon (for surface and orbiting payloads), the payload will have a medium gain patch antenna operating at S-band for one of the lunar proximity links at a low data rate; this link will also service a variety of navigation needs, including ranging and timing operations between the spacecraft and users. The payload will also have a high-gain directed antenna operating at Ka-band for the high data rate portion of the proximity link.

The attached Schedule S specifies all RF characteristics.

6. GROUND SEGMENT

The Parsec system will use third-party Earth stations to communicate globally on the requested X and Ka-band frequencies and is compatible with NASA's Deep Space Network for additional Earth station options and dedicated support for NASA missions. Only when the Parsec satellites are within line of sight of any authorized Earth station will data be relayed in both the space-to-Earth and Earth-to-space directions to provide connectivity for that segment of the mission service. All Earth stations in consideration will be coordinated and authorized to operate at the defined frequencies by the applicable jurisdiction.[11] Table 4 specifies initial Parsec Earth station locations. Should additional Earth stations become necessary, Lockheed Martin requests to notify the

[10] The software-defined radios will enable frequency agility within the specified bands in order to service multiple lunar users each on their own frequencies.
[11] When the second spacecraft is added, Lockheed Martin may add more Earth stations after completing frequency coordination.

Commission of completion of any required coordination in lieu of seeking a license modification.[12]

Location	Coordinates
Goonhilly, United Kingdom	50.0482° N, 5.1810° W
Perth, Australia	31.9523° S, 115.8613° E
Phoenix, Arizona, United States	33.4484° N, 112.0740° W

Table 4: Parsec Earth Stations

On average over a lunar month, the affiliated Earth stations can provide 97.2% coverage of the Moon (where at least one station has visibility). The Moon will be simultaneously visible from two of the three stations 22.5% of the time.

7. PUBLIC INTEREST CONSIDERATIONS

Quality cislunar communications services are critical to progress in lunar exploration and economic development. The Parsec system will serve a variety of users, including U.S. and international governments and various commercial users. Most important, it will enable American leadership in the many planned missions that will bring a regular commercial supply of materials and experiments to the Moon; ensure successful future landings by crewed spacecraft; increase safety by providing real-time communications; and deliver data from lunar experiments to Earth in a timely way. Grant of this application will enhance the communications capabilities for missions that will bring unique and valuable scientific and engineering payloads to the lunar surface. Parsec will help these missions achieve the full capabilities of science, exploration, and commercial development.

8. ORBITAL DEBRIS MITIGATION STRATEGY

Attachment A demonstrates the Parsec system will satisfy FCC orbital debris mitigation standards.[13]

[12] *See, e.g.*, Spire Global, Inc., Stamp Grant, IBFS File No. SAT-MOD-20200603-00065, at Condition 18 (granted Jan. 31, 2022); Loft Orbital Solutions Inc., Stamp Grant, IBFS File No. SAT-LOA-20200907-00105, at Condition 14 (granted May 24, 2021).
[13] *See generally Mitigation of Orbital Debris in the New Space Age*, Report and Order et al., 35 FCC Rcd 4156 at Appendix A (2020).

9. WAIVER REQUESTS

The Commission may waive rule compliance if "good cause" exists.[14] Waiver is appropriate where "special circumstances warrant a deviation from the general rule and such deviation will serve the public interest" better than strict adherence to the rule.[15] In general, the Commission grants a waiver if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.[16] Potential hardship, equity, or policy implementation factors may influence the waiver decision.[17] Additionally, the Commission generally grants a waiver of the table of frequency allocations "when there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services."[18] Good cause exists to waive the following rules to the extent necessary to consider and grant the petition.

A. 47 C.F.R. § 2.106 (U.S. Frequency Allocation Table)

Lockheed Martin requests waiver of the U.S. frequency allocation table to use the 2200-2290 MHz and 7190-7235 MHz bands because both omit non-federal service allocations.[19] Lockheed Martin accepts any interference from authorized services in this spectrum and believes that its Parsec service will enable interoperability with NASA and other customers.

i. 2200-2290 MHz (space-to-Earth)

In the 2200-2290 MHz band, non-federal systems may only communicate with the Tracking and Data Relay Satellite System ("TDRSS") in the 2285-2290 MHz segment on a case-by-case basis.[20] The Parsec system will communicate with non-TDRSS satellites and will use band segments outside 2285-2290 MHz. Permitting the non-conforming operations is justified.

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[14] *See* 47 C.F.R. § 1.3; *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990); *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969).
[15] *Northeast Cellular*, 897 F.2d at 1166.
[16] *WAIT Radio*, 418 F.2d at 1157.
[17] *Id.* at 1159.
[18] *The Boeing Company Application for Blanket Authority to Operate Up to Eight Hundred Technically Identical Transmit and Receive Mobile Earth Stations Aboard Aircraft in the 14.0-14.5 GHz and 11.7-12.2 GHz Frequency Bands*, Order and Authorization, 16 FCC Rcd 22645 ¶ 12 (IB & OET 2001) (internal punctuation omitted). *See generally Application of Fugro-Chance, Inc. for Blanket Authority to Construct and Operate a Private Network of Receive-Only Mobile Earth Stations*, Order and Authorization, 10 FCC Rcd 2860 (IB 1995); *Application of Motorola Satellite Communications, Inc. for Modification of License*, Order and Authorization, 11 FCC Rcd 13952 (IB 1996).
[19] *See* 47 C.F.R. § 2.106.
[20] *See* 47 C.F.R. § 2.106 n.US303.

Interference, if any, would prove imperceptible and would never rise to the level of harmful interference. In the 2200-2290 MHz band, Moon-orbiting Parsec satellites will only communicate with assets on or serving the Moon, approximately 340,000 km from the geostationary arc and 380,000 km from low-Earth orbits and Earth's surface. The large separation distance ensures only faint signals enter Earth's orbits and helps satisfy the relevant power-flux density limit at the Earth's surface.[21] To further lessen interference risk, the use of filtered BPSK and/or QPSK modulation and channel coding will reduce power spectral density, as recommended by the Space Frequency Coordination Group, which includes U.S. federal agencies.[22] Although near-zero interference risk remains after implementing these operational practices, Lockheed Martin will coordinate the proposed frequencies to eliminate all potential risk.

A waiver ensures interoperability and continued U.S. space leadership. For lunar service equipment, customers, such as NASA's LunaNet, require access to the entirety of the 2200-2290 MHz band, which is paired with the 2025-2110 MHz band. Furthermore, all three ITU regions permit space research service space-to-space links in the band. Restricting the proposed spectrum use in the United States would reduce American leadership in lunar exploration because other administrations do not impose similar constraints on their commercial operators.

ii. 7190-7235 MHz (Earth-to-space)

In the 7190-7235 MHz band, the U.S. frequency allocation table omits a satellite service allocation for non-federal use, and the international frequency allocation table bans space research service for deep space missions.[23] Lockheed Martin proposes to deliver space research service using this band for a non-deep space mission.[24] Permitting the non-conforming operations is justified.

Similar to the 2200-2290 MHz band, interference risk remains non-existent in the 7190-7235 MHz band. The limited number of earth stations using this spectrum would transmit to the two Parsec satellites only when in line of sight for short duty cycles. To ensure co-frequency federal systems experience no service degradation, Lockheed Martin will complete coordination with the relevant agency spectrum users.

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[21] *See* ITU RR Table 21-4. *See also infra.* Appendix B.

[22] *See, e.g.*, *Interference from Space-to-Space Links between Non-geostationary Satellites to Other Space Systems in the 2025-2110 and 2200-2290 MHz Bands*, SFCG (Oct. 20, 2005), https://bit.ly/38UT26J. *See generally Space Communications Cross Support – Architecture Requirements Document*, CCSDS (May 2015), https://bit.ly/2INYVIw.

[23] *See* 47 C.F.R. § 2.106 n.5.460.

[24] A deep space mission operates "at distances from the Earth equal to, or greater than, 2×10^6 km." ITU RR No. 1.177. The Parsec satellites are not deep space missions because they will operate approximately 385,000 km from the Earth's surface to support lunar communications or data storage.

Similar to the 2200-2290 MHz band, a waiver for the 7190-7235 MHz band permits interoperability and continued U.S. space leadership. For lunar service equipment, customers, such as NASA's LunaNet, require access to the entirety of the 7190-7235 MHz band, which is paired with the 8450-8500 MHz band. Furthermore, all three ITU regions permit space research service Earth-to-space links in the band. Restricting such use in the United States would reduce American leadership in lunar exploration because other administrations do not impose similar constraints on their commercial operators.

B. 47 C.F.R. § 25.114(c)(6) (Orbital Parameters)

For an NGSO license application, the Commission requests specific orbital parameters (altitude and inclination, for example).[25] Given the fact that exact orbital parameters will be customer-driven and launch-provider specific for the Parsec launch, Lockheed Martin seeks a waiver to submit an orbital range (see Table 3), including representative figures in the attached Schedule S, for the final operational orbit near the Moon.

Good cause supports this rule deviation. For other NGSO systems with unknown launch parameters, the Commission authorized an NGSO range to afford flexibility.[26] In those situations, applicants analyzed various orbits, including a worst-case scenario, to demonstrate the proposal would not disturb the Earth-orbit environment.[27] Lockheed Martin does the same in Attachment A for a significantly less crowded Moon-orbit environment. Furthermore, denying the waiver would encourage applicants to submit applications late, only after resolving orbital parameters and, in turn, squeeze limited FCC resources to rush process novel, sophisticated missions. To avoid such considerations and reduce administrative burden, Lockheed Martin submits the Parsec application early without orbits finalized.

[25] *See* 47 C.F.R. § 25.114(c)(6).

[26] *See, e.g.*, Spire Global, Inc., Stamp Grant, IBFS File No. SAT-MOD-20200603-00065 (granted Jan. 31, 2022) (authorizing 122 simultaneously operational satellites at altitudes between 385 km and 650 km low-Earth orbit); Planet Labs Inc., Stamp Grant, IBFS File No. SAT-MOD-20170713-00103 (granted July 17, 2018) (authorizing 200 simultaneously operational satellites at altitudes between 350 km and 660 km low-Earth orbit).

[27] *See generally* Spire Global, Inc., Application, IBFS File No. SAT-MOD-20200603-00065, at Exhibit C - ODAR (filed July 22, 2020); Planet Labs Inc., Application, IBFS File No. SAT-MOD-20170713-00103, Flock Aggregate Orbital Debris Assessment Report (filed Jan. 19, 2018) and Planet Labs Inc., Application, IBFS File No. SAT-MOD-20170713-00103, Collision Avoidance Statement (filed Apr. 10, 2018).

C. 47 C.F.R. §§ 25.156, 25.157 (NGSO Processing Round)

The Commission administers processing rounds to adjudicate NGSO satellite system applications for non-federal frequencies.[28] However, it also authorizes exceptions when appropriate. Processing rounds are unnecessary for systems able to share frequencies with existing co-frequency NGSO systems without precluding additional entry by future co-frequency NGSO systems.[29] In these cases, the Commission processes NGSO satellite system applications under the first-come, first-served procedure adopted for GSO satellite systems.[30] Parsec's communications crossing Earth orbit and Moon orbit would neither constrain current operators nor preclude future entrants in any bands proposed here and should receive consideration outside a processing round.

i. Earth-orbit communications

The Commission has previously authorized Earth-orbit NGSOs outside a processing round. Those waiver requests were supported by the understanding that the systems were fully capable of sharing with current and future NGSO systems in the same frequency bands[31] and, therefore, no mutual exclusivity existed.

Parsec will operate no differently. Spectrum sharing will be possible because the Parsec satellites and affiliated earth stations and other systems' satellites and their respective earth stations communicate only for short periods of time while visible from the partnering satellites and earth stations. For harmful interference to occur, satellites and earth stations belonging to other systems would have to travel through the antenna beam of Parsec's satellites and earth stations and transmit or receive at the exact same time. In such an unlikely event, the resulting interference could be avoided by coordinating the communications so that they do not occur simultaneously.

ii. Moon-orbit communications

Parsec satellites will communicate with only space assets on the Moon or in the Moon's orbit. For similar space-to-space links, processing rounds were waived. Audacy, for example, received the waiver because its few satellites, alongside the limited duration and spatial separation of communications with third-party customer satellites, would ease coordination.[32] The same applies here. Given the Moon's distant location from the RF-congested environment on and surrounding the Earth and limited number of

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[28] *See* 47 C.F.R. §§ 25.156, 25.157.
[29] *See, e.g.*, *Space Imaging, LLC*, 20 FCC Rcd 11964 ¶ 11 (IB 2005); *DigitalGlobe, Inc.*, Order and Authorization, 20 FCC Rcd 15696 ¶ 8 (IB 2005).
[30] *See* 47 C.F.R. § 25.158.
[31] *See, e.g.*, *Space Imaging, LLC*, 20 FCC Rcd 11964 ¶ 11 (IB 2005); *DigitalGlobe, Inc.*, Order and Authorization, 20 FCC Rcd 15696 ¶ 8 (IB 2005).
[32] *See, e.g.*, *Audacy Corporation*, Order and Authorization, 33 FCC Rcd 5554 ¶¶ 26-27 (2018); *see also, e.g.*, *The Boeing Company*, Order and Authorization, IBFS File No. SAT-LOA-20170301-00028, FCC 21-115 ¶ 21 (adopted Nov. 3, 2021).

space assets that might operate simultaneously near the Moon, spectrum sharing is possible. Furthermore, Lockheed Martin will coordinate the frequencies with existing co-frequency operators and cooperate fully with any future co-frequency systems consistent with precedent and the inter-satellite service coordination rule.[33]

10. ADDITIONAL INFORMATION

A. ITU Requirements

For systems it issues launch-and-operational authority, the Commission submits advance publication information to the ITU.[34] In concert with this application, Lockheed Martin submits the ITU API and, in Attachment C, unconditionally accepts all associated cost recovery responsibilities.

B. Ownership Information

Lockheed Martin's ownership structure appears in Attachment D.

11. CONCLUSION

Lockheed Martin aims to deploy the world's first commercial lunar communications relay service. Authorizing the Parsec system before its third-quarter 2023 launch would advance U.S. leadership in space science and commerce.

Respectfully submitted,

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[33] *See* 47 C.F.R. § 25.279.
[34] *See* 47 C.F.R. § 25.111.

Attachment A
(Orbital Debris Rule Compliance)

Keeping space safe and sustainable is paramount to Lockheed Martin. Consistent with this mission, the Parsec system will satisfy the FCC's orbital debris mitigation rules in 47 C.F.R. § 25.114(d)(14), as amended recently, to ensure safe design build, minimize collision risk, and achieve post-mission disposal success.[1]

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)	A description of the design and operational strategies that will be used to mitigate orbital debris, including the following information	See following rows.
25.114(d)(14)(i)	A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris	Lockheed Martin has assessed and limited the amount of debris released in a planned manner during normal operations.
25.114(d)(14)(ii)	A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool	The probability that a single Parsec satellite will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal is less than 0.00348 (1 in 287).

[1] *See generally Mitigation of Orbital Debris in the New Space Age*, Report and Order et al., 35 FCC Rcd 4156 at Appendix A (2020).

[2] For all calculations, Lockheed Martin used National Aeronautics and Space Administration Debris Assessment Software v.3.2.0.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iii)	A statement that the space station operator has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application	Lockheed Martin has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. Prior to spacecraft shutdown at the end of mission life, Parsec satellites will perform a series of operations to mitigate the risk of additional debris generation. The vehicle will deplete all residual fuel and vent all pressurized systems, and batteries will be placed in a permanent discharge state. By performing these discharge operations and disposal maneuvers, the risk of accidental explosion or liquid release is significantly reduced.
25.114(d)(14)(iv)	A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations	Lockheed Martin has assessed and limited the probability of the Parsec satellites becoming a source of debris by collisions with large debris or other operational space stations.
25.114(d)(14)(iv)(A)	Where the application is for an NGSO space station or system, the following information must also be included	See following rows.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(A)(1)	A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects	The probability of collision between any Parsec satellite and other large objects (10 cm or larger in diameter) during the total orbital lifetime of a single Parsec satellite, including any de-orbit phases, is less than 2.25E-10 (1 in 4.4 billion).
25.114(d)(14)(iv)(A)(2)	The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision	The Parsec satellites will operate in lunar orbit where only few government spacecraft operate. To mitigate collision risk between Parsec satellites and other current and future lunar orbiting spacecraft, Lockheed Martin will coordinate physical orbit operations with the owner/operators of the other lunar orbiting spacecraft. Lockheed Martin has experience of such coordination with NASA/JPL and Goddard, ESA, LASP/United Arab Emirates, and ISRO (India) in other mission contexts. Updated orbital information is shared across the respective teams to permit the performance of “Close Approach” analysis and further coordination if an expected close approach is below a certain threshold.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(A)(3)	If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft	N/A. The Parsec satellites—operating only in lunar orbit—will not cross orbital altitudes of any inhabitable spacecraft in low-Earth orbit. Should any inhabitable spacecraft operate in lunar orbit, Lockheed Martin will coordinate physical orbit operations.
25.114(d)(14)(iv)(A)(4)	The statement must disclose the accuracy, if any, with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *e.g.,* its propulsion system will not be used for orbital maintenance, that fact must be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems must describe the extent of satellite maneuverability, whether or not the space station design includes a propulsion system	Throughout the mission, Parsec satellites will operate in a stable elliptical frozen orbit around the Moon and will use onboard chemical propulsion to perform orbit maintenance as necessary to remain within the bounds of the frozen orbit. Parsec has a chemical propulsion system capable of orbit maintenance maneuvers throughout the life of the mission, to ensure semi-major axis, eccentricity, inclination, and argument of periapsis.
25.114(d)(14)(iv)(A)(5)	The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: Contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations	Lockheed Martin certifies that upon receipt of a space situational awareness conjunction warning it will review and take all possible steps to assess the collision risk and will mitigate the collision risk if necessary. Operational practices include, among other things, Lockheed Martin contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying Parsec satellite attitude and/or operations.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(iv)(B)	Where a space station requests the assignment of a geostationary orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those satellites and the measures that will be taken to prevent collisions	N/A. Parsec satellites will not operate in the geostationary orbit.
25.114(d)(14)(v)	A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, excluding deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following	Each Parsec satellite measures 72 centimeters in its smallest dimension.
25.114(d)(14)(v)(A)	How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive	Lockheed Martin will employ active tracking to identify the Parsec satellites after deployment. Immediately following deployment, the associated ground stations will begin receiving trajectory data from the launch provider and will adjust their pointing based on the current ephemeris in order to identify the Parsec spacecraft by assigned TT&C frequency channels.
25.114(d)(14)(v)(B)	Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity	Lockheed Martin will register the Parsec satellites with the 18th Space Control Squadron or successor entity.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(v)(C)	The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators	Lockheed Martin will share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.
25.114(d)(14)(vi)	A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks	N/A. Parsec satellites will not participate in physical proximity operations.
25.114(d)(14)(vii)	A statement detailing the disposal plans for the space station, including the quantity of fuel - if any - that will be reserved for disposal maneuvers. In addition, the following specific provisions apply	Lockheed Martin plans to reserve approximately 3.5 kilograms of fuel for the controlled impact burn disposal option discussed below. Lockheed Martin plans to reserve approximately 11 kilograms of fuel for the heliocentric trajectory orbit disposal option discussed below.
25.114(d)(14)(vii)(A)	For geostationary orbit space stations, the statement must disclose the altitude selected for a disposal orbit and the calculations that are used in deriving the disposal altitude	N/A. Parsec satellites will not operate in the geostationary orbit.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(B)	For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission	N/A. Parsec satellites will not terminate operations in low-Earth orbit.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(C)	For space stations not covered by either paragraph (d)(14)(vii)(A) or (B) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan	Parsec satellites will perform one of two post-mission disposal maneuvers to mitigate the risk of orbital debris. Both maneuver options have been evaluated and analyzed by the Parsec team, and each Parsec spacecraft is capable of both maneuvers. One method of spacecraft disposal is to perform a controlled impact burn to impact the lunar surface in a Category I planetary protection location, staying outside controlled Category II planetary protection locations, similar to the NASA GRAIL spacecraft disposal; this disposal requires roughly 80 m/s delta-V.[3] A second method of spacecraft disposal is to perform a two-stage propulsive burn to reach a heliocentric trajectory at mission completion; this trajectory requires approximately 180 m/s delta-V and has been propagated for 50 years to ensure the spacecraft does not re-enter the Earth-Moon system within that time frame. This second method would reasonably be expected to satisfy NASA-STD-8719.14C, as it relates to long-term reentry in other orbits and to disposal orbit risks.

[3] *See, e.g.*, Nicholas Johnson et al., *Orbital Debris Mitigation Requirements and the GRAIL Spacecraft*, CORE at 68, https://bit.ly/33na1SL (last viewed Feb. 15, 2022).

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(D)	For all space stations under paragraph (d)(14)(vii)(B) or (C) of this section, the following additional specific provisions apply	See following rows.
25.114(d)(14)(vii)(D)(1)	The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (d)(14)(vii)(B) of this section, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (d)(14)(vii)(C) of this section, successful disposal will be assessed on a case-by-case basis	Each Parsec satellite is equipped with a high-reliability flight-heritage propulsion system capable of each of the above-referenced disposal burn options at end of life with a greater than 0.9 probability.
25.114(d)(14)(vii)(D)(2)	If planned disposal is by atmospheric re-entry, the statement must also include	N/A. Parsec satellites will not terminate operations by atmospheric Earth re-entry.
25.114(d)(14)(vii)(D)(2)(a)	A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry	N/A. Parsec satellites will not terminate operations by atmospheric Earth re-entry.
25.114(d)(14)(vii)(D)(2)(b)	An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000)	N/A. Parsec satellites will not terminate operations by atmospheric Earth re-entry.

Rule Subsection	Rule Text	Compliance[2]
25.114(d)(14)(vii)(E)	Applicants for space stations to be used only for commercial remote sensing may, in lieu of submitting detailed post-mission disposal plans to the Commission, certify that they have submitted such plans to the National Oceanic and Atmospheric Administration for review	N/A. Parsec satellites will not carry imaging equipment and, therefore, require no NOAA licensing.
25.114(d)(14)(viii)	For non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority	N/A. The United States will authorize the Parsec satellites.

Attachment B
(Section 25.208 power-flux-density analysis)

Frequency	**2025-2110**	**MHz**						
Minimum range (km)	339655.7	km						
PFD Limits	Arrival Angle (°)	Range (km)	Spreading loss (dB)	2 GHz Article 21 limit (dBW/4kHz)	Corresponding eirpd limit (dBW/Hz)	max eirpd (dBW/Hz)	Actual pfd produced (dBW/4Hz)	Margin (dB)
	5	345419	181.8	-154.0	-8.2	-29.9	-175.7	21.7
	10	344869	181.7	-151.5	-5.8	-29.9	-175.6	24.1
	15	344328	181.7	-149.0	-3.3	-29.9	-175.6	26.6
	20	343800	181.7	-146.5	-0.8	-29.9	-175.6	29.1
	25	343290	181.7	-144.0	1.7	-29.9	-175.6	31.6
	50	341124	181.7	-144.0	1.7	-29.9	-175.6	31.6
	90	339656	181.6	-144.0	1.6	-29.9	-175.5	31.5

Frequency	**8450-8500**	**MHz**						
Minimum range (km)	339655.7							
PFD Limits	Arrival Angle (°)	Range (km)	Spreading loss (dB)	8 GHz Article 21 limit (dBW/4kHz)	Corresponding eirpd limit (dBW/Hz)	max eirpd (dBW/Hz)	Actual pfd produced (dBW/4Hz)	Margin (dB)
	5	345419	181.8	-150.0	-4.2	-26.6	-172.4	22.4
	10	344869	181.7	-147.5	-1.8	-26.6	-172.3	24.8
	15	344328	181.7	-145.0	0.7	-26.6	-172.3	27.3
	20	343800	181.7	-142.5	3.2	-26.6	-172.3	29.8
	25	343290	181.7	-140.0	5.7	-26.6	-172.3	32.3
	50	341124	181.7	-140.0	5.7	-26.6	-172.3	32.3
	90	339656	181.6	-140.0	5.6	-26.6	-172.2	32.2

Frequency	**23.15-23.55**	**GHz**						
Minimum range (km)	339655.7							
PFD Limits	Arrival Angle (°)	Range (km)	Spreading loss (dB)	23 GHz Article 21 limit (dBW/MHz)	Corresponding eirpd limit (dBW/Hz)	max eirpd (dBW/Hz)	Actual pfd produced (dBW/MHz)	Margin (dB)
	5	345419	181.8	-115.0	6.8	-29.5	-151.3	36.3
	10	344869	181.7	-112.5	9.2	-29.5	-151.2	38.7
	15	344328	181.7	-110.0	11.7	-29.5	-151.2	41.2
	20	343800	181.7	-107.5	14.2	-29.5	-151.2	43.7
	25	343290	181.7	-105.0	16.7	-29.5	-151.2	46.2
	50	341124	181.7	-105.0	16.7	-29.5	-151.2	46.2
	90	339656	181.6	-105.0	16.6	-29.5	-151.1	46.1

Frequency	**25.5-27.0**	**GHz**						
Minimum range (km)	339655.7							
PFD Limits	Arrival Angle (°)	Range (km)	Spreading loss (dB)	26 GHz Article 21 limit (dBW/MHz)	Corresponding eirpd limit (dBW/Hz)	max eirpd (dBW/Hz)	Actual pfd produced (dBW/MHz)	Margin (dB)
	5	345419	181.8	-115.0	6.8	-31.6	-153.4	38.4
	10	344869	181.7	-112.5	9.2	-31.6	-153.3	40.8
	15	344328	181.7	-110.0	11.7	-31.6	-153.3	43.3
	20	343800	181.7	-107.5	14.2	-31.6	-153.3	45.8
	25	343290	181.7	-105.0	16.7	-31.6	-153.3	48.3
	50	341124	181.7	-105.0	16.7	-31.6	-153.3	48.3
	90	339656	181.6	-105.0	16.6	-31.6	-153.2	48.2

Frequency	**27.0-27.5**	**GHz**						
Minimum range (km)	339655.7							
PFD Limits	Arrival Angle (°)	Range (km)	Spreading loss (dB)	26 GHz Article 21 limit (dBW/MHz)	Corresponding eirpd limit (dBW/Hz)	max eirpd (dBW/Hz)	Actual pfd produced (dBW/MHz)	Margin (dB)
	5	345419	181.8	-115.0	6.8	-31.6	-153.4	38.4
	10	344869	181.7	-112.5	9.2	-31.6	-153.3	40.8
	15	344328	181.7	-110.0	11.7	-31.6	-153.3	43.3
	20	343800	181.7	-107.5	14.2	-31.6	-153.3	45.8
	25	343290	181.7	-105.0	16.7	-31.6	-153.3	48.3
	50	341124	181.7	-105.0	16.7	-31.6	-153.3	48.3
	90	339656	181.6	-105.0	16.6	-31.6	-153.2	48.2

Attachment C
(ITU Cost Recovery Declaration)

Lockheed Martin Corporation
2121 Crystal Drive #100 Arlington, VA 22202
Telephone 703•413•5747 Mobile 571•255•9651

Ryan N. Terry
Director, Regulatory Strategy, Licensing & Policy
Civil & Regulatory Affairs

February 18, 2022

Secretary
Office of the Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Subject: ITU Cost Recovery Declaration for the Parsec Non-Geostationary Orbit Satellite System in Non-Planned Frequency Bands

Dear Madame Secretary:

Lockheed Martin Corporation (Lockheed Martin) is aware that in accordance with Resolution 88 of the International Telecommunication Union (ITU) Plenipotentiary Conference (Marrakech, 2002), and ITU Council Decision 482, as modified, cost-recovery fees will apply to satellite network filings received by the Radiocommunications Bureau after November 7, 1998. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU to process their satellite network filings.

Lockheed Martin hereby states that it is aware of this requirement and unconditionally accepts all cost recovery responsibilities associated with the ITU filings for the Parsec satellite system. Please address all cost-recovery inquires, and ITU correspondence and filings, related to the Parsec satellite system to the following point of contact. We understand that should there be any change in the point of contact information we will inform the Commission within 30 days of the foreseen event.

Point of Contact Name: Ryan N. Terry

Organization Name: Lockheed Martin Corporation

Address: 2121 Crystal Drive
Suite 100
Arlington, VA 22202
USA

E-Mail: ryan.n.terry@lmco.com

Telephone Number: 703-413-5747

Lockheed Martin understands that it must remit payment of any resultant cost-recovery fee to the ITU by the due date specified in the ITU invoice, unless an appeal filed prior to the due date is pending with the ITU. We fully understand that a license granted in reliance on such a commitment will be conditioned upon discharge of any such cost-recovery obligation. We also acknowledge that, in accordance with 47 C.F.R. § 25.111, should we have an overdue ITU cost-recovery fee and have no appeal pending with the ITU, the Commission may dismiss any application associated with that satellite network.

Respectfully submitted,

/s/ Ryan Neels Terry

Ryan N. Terry
Director, Regulatory Strategy, Licensing & Policy
LOCKHEED MARTIN CORPORATION
2121 Crystal Drive
Suite 100
Arlington, VA 22202, USA
703-413-5747

Attachment D
(Ownership Information)

Lockheed Martin Corporation ("Lockheed Martin") is a privately held corporation. The following individuals hold 10% or more of the equity and/or voting interest in Lockheed Martin.

Shareholder	Citizenship or Country of Incorporation	Equity and/or Voting Interest Percentage
State Street Corporation	USA	14.8%

The following individuals are Lockheed Martin's board directors.

Name	Citizenship
James D. Taiclet	USA
Daniel F. Akerson	USA
David B. Burritt	USA
Bruce A. Carlson	USA
John M. Donovan	USA
Joseph F. Dunford, Jr.	USA
James O. Ellis, Jr.	USA
Thomas J. Falk	USA
Ilene S. Gordon	USA
Vicki A. Hollub	USA
Jeh C. Johnson	USA
Debra L. Reed-Klages	USA
Patricia E. Yarrington	USA

The following individuals are Lockheed Martin's officers.

Name	Title	Citizenship
James D. Taiclet	Chairman, President & CEO	USA
Jesus Malave	CFO	USA
Frank A. St. John	COO	USA
Scott Greene	EVP, Missiles and Fire Control	USA
Stephanie C. Hill	EVP, Rotary and Mission Systems	USA
Maryanne Lavan	SVP, General Counsel and Corporate Secretary	USA
Robert Lightfoot	EVP, Space	USA
Gregory M. Ulmer	EVP, Aeronautics	USA

All Lockheed Martin board directors and officers may be reached at the address below.

Lockheed Martin Corporation
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