Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Lockheed Martin Corporation	)	File No. SAT-LOA- __________
	)	
Request for Authority to Launch and Operate Blanket Licensed Lunar Surface Space Stations	)))	Call Sign __________

APPLICATION

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March 15, 2023

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APPLICATION

Lockheed Martin Corporation ("Lockheed Martin") seeks launch and operational authority for 230 lunar surface space stations[1] that would communicate with (a) each other; (b) Lockheed Martin's lunar orbit satellites branded "Parsec™" and other authorized satellites;[2] and/or (c) Earth stations and other space stations using UHF, S-, X-, and/or Ka-band spectrum for scientific and commercial purposes.[3] Approving this application is in the public interest as it would advance lunar and cislunar research and exploration while cementing American leadership in space commerce and science.

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

A. Phase Deployment

Lunar surface space stations would deploy in three phases with the radiofrequency and space debris profile dictating the schedule.

- Phase 1 space stations (see Table 1) have a low-impact radiofrequency and space debris profile.
- Phase 2 space stations (see Table 2) have a medium-impact radiofrequency or space debris profile.

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[1] For clarity, Lockheed Martin seeks authority for 230 Phase 1 space stations and respectfully requests that the Commission permit Lockheed Martin to notify the number of Phase 2 space stations once these values are determined.

[2] *See generally* Lockheed Martin, Application, IBFS File No. SAT-LOA-20220218-00020 (filed Feb. 18, 2022). This supporting document generally refers to the satellite system as Parsec.

[3] *See* 47 C.F.R. § 25.114(a)(2) (accepting blanket license applications for non-technically identical space stations).

- Phase 3 space stations (see Table 3) have a high-impact radiofrequency profile.

Lockheed Martin requests expeditious authorization of Phase 1 space stations and deferred action on Phase 2 space stations if FCC consideration of Phase 2 would substantially delay action on the initial license grant. Phase 3 space stations appear for informational awareness and future consideration. Expeditious action on the Phase 1 request would provide critical operational information for both the remaining phases of this application as well as for the U.S. space program in general. Elements of each phase are described in the following tables.

Table 1: Phase 1 Space Stations

Space Station ID	Total Number Requested	Space Station Type	Description	Examples
LS 1.1 (robotic landers and payloads)	50	Fixed	Uncrewed vehicles and payloads containing scientific instruments, experiments and technology demonstrations or infrastructure	Lunar Vertical Solar Array Technology (“LVSAT”) demos Commercial Lunar Payload Services (“CLPS”) missions
LS 1.2 (lunar mobility vehicles)	20	Mobile	Uncrewed or crewed vehicles transiting the lunar surface	Lunar Terrain Vehicle (“LTV”) teams CLPS payloads
LS 1.3 (human landing system)	40	Fixed	Crewed system with both ascent and descent elements to land crew on lunar surface and return crew to orbiting space stations	10x Artemis missions (with 2x ascent and 2x descent for each)
LS 1.4 (spacesuits)	40	Mobile	Protective outerwear for each crew member that communicates health, lunar mapping, and other mission information with other	10x Artemis missions (with 4x astronauts for each)

Space Station ID	Total Number Requested	Space Station Type	Description	Examples
			crewmembers' outerwear	
LS 1.5 (handheld terminals)	80	Fixed and Mobile	Small devices for crew to communicate with each other both inside and outside the lunar habitat	10x Artemis missions (with 4x astronauts and 2x redundancy for each)

Table 2: Phase 2 Space Stations[4]

Space Station ID	Total Number Requested	Space Station Type	Description	Examples
LS 2.1 (in-space manufacturing assets)	TBD	Fixed and mobile	Uncrewed equipment manufacturing and assembling tools	3D-printing robotic arms and other deployables
LS 2.2 (in-situ resource utilization assets)	TBD	Fixed and mobile	Uncrewed equipment extracting and repurposing lunar surface resources and raw materials	Extracting ice and water from the lunar surface and converting them into propellant for refueling
LS 2.3 (expanded application of robotic rovers)	TBD	Mobile	Uncrewed vehicles transiting the Moon	NASA Volatiles Investigating Polar Exploration Rover ("VIPER") successor

[4] TBD values cannot yet be accurately projected and instead will be better known as market needs of the lunar ecosystem become more certain. Lockheed Martin respectfully requests that the Commission permit it to notify of the number of units at a future point once these values are determined.

Table 3: Phase 3 Space Stations[5]

Space Station ID	Total Number Requested	Space Station Type	Description	Examples
LS 3.1 (fission-surface-power support)	TBD	Fixed	Uncrewed fission technology power plant communications with nearby lunar surface assets and Earth stations for power plant health and status information	NASA Kilopower Project
LS 3.2 (habitation-system support)	TBD	Fixed	Extended crew mission communications inside a habitat and with nearby lunar surface assets and Earth stations for human health and status information	NASA Lunar Surface Habitat

B. Frequency Plan

No one radiocommunication service or frequency band can host all lunar surface communications. At least three international bodies with U.S. representation, including both space and terrestrial interests, have already recognized this reality and spent considerable resources establishing a common frequency plan that might best host lunar communications.

Spectrum Frequency Coordination Group ("SFCG"). The SFCG membership—including 34 of the world's leading space and science agencies and 11 observer delegations—generated SFCG 32-2R4, a recommendation on communications frequency allocations and sharing in the lunar region.[6]

[5] A subsequent license modification application to initiate Phase 3 operations would provide this number and further information on the concept of operations.

[6] *See SFCG Membership*, Space Frequency Coordination Group, https://bit.ly/3Iyqx2u (last viewed Feb. 18, 2023); Communication and Positioning, Navigation, and Timing Frequency Allocations and Sharing in the Lunar Region, Recommendation, SFCG 32-2R4 at Table 1 (Jul. 27, 2022), https://bit.ly/3Z3LdpN.

Council of the Consultative Committee for Space Data Systems ("CCSDS"). The CCSDS membership—including 11 member and 33 observer space and science agencies—finalized CCSDS 883.0-B-1, a recommended standard for space data systems, including lunar region systems using high data rate 3GPP and Wi-Fi local area communications.[7]

Interagency Operations Advisory Group ("IOAG") Lunar Communications Architecture Working Group. The IOAG membership—including 19 representatives from various space and science agencies—prepared a report on the future lunar communications architecture.[8]

These organizations and NASA (in its LunaNet plan)[9] thoughtfully targeted the frequencies proposed in this application. Other than the lunar surface-only communication frequencies, the bands (2.0, 2.2, 7, 8, 22, 23, 26, and 27 GHz) are allocated for very similar existing space service types (space research service (space-to-space) or inter-satellite service, for example). Use of the lunar surface-only frequencies (such as the 2.4 and 5 GHz radio local access network ("RLAN") bands and the 2.5 and 3.4 GHz 5G bands) would not impede Earth surface operations given significant space path loss and other radiofrequency attenuating factors.

The band selections in this application ensure the highest degree of interoperability among all existing and planned communication assets of all participating agencies and companies while meeting various communications requirements and satisfying critical technical and financial objectives.[10] This commonality between earth and lunar frequencies leads to cost reductions in hardware and testing. Operation on these frequencies would be an important step in development of space resources and give critical operational guidance for future space activities.

Interoperability. The SFCG recognized that "the major benefit of an agreed frequency plan for the lunar region enables interoperability and sharing of communications and

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[7] *See* Spacecraft Onboard Interface Services— High Data Rate 3GPP and Wi-Fi Local Area Communications, Recommended Standard CCSDS 883.0-B-1, Consultative Committee for Space Data Systems at iv, Table 3-1 (Feb. 2022), https://bit.ly/3Abcb5X.

[8] *See* The Future Lunar Communications Architecture, Report, Interagency Operations Advisory Group Lunar Communications Architecture Working Group at 2, Table 4 (Jan. 31, 2022), https://bit.ly/39YHW7D.

[9] *See LunaNet Overview*, NASA, at slide 5 (presented June 7-9, 2022), https://go.nasa.gov/3BiYS3C.

[10] *See generally* Communication and Positioning, Navigation, and Timing Frequency Allocations and Sharing in the Lunar Region, Recommendation SFCG 32-2R4 (Jul. 27, 2022), https://bit.ly/3Z3LdpN.

[position, navigation, and timing] infrastructure and service assets to support individual or joint exploration missions to accomplish complex objectives."[11]

Mission requirements. The SFCG further explained that "multiple frequency bands are needed for missions to meet various communications requirements and satisfy cost, mass and performance objectives."[12] However, "separate frequencies are needed in the lunar region for compatible local communications between a surface vehicle and an orbiter, between surface vehicles, and between orbiters."[13] "Sufficient frequency separation is required to enable compatible and simultaneous communications for a multiplicity of spacecraft in the lunar region with each other, earth stations, [lunar relay satellites], local lunar based vehicles, a lunar outpost and lunar vehicles transmitting to an earth station."[14] The SFCG also noted that "lower frequency provides better [signal-to-noise ratio] performance for a communication link between two vehicles using low gain broad beam antennas" while "higher frequency provides wider bandwidth and higher data throughput performance between two vehicles employing high gain antennas."[15]

Desired equipment availability at scale. For its part, the CCSDS noted that "3GPP LTE based products are widely utilized terrestrially with a large [commercial off-the-shelf] provider base and attendant reliability. 3GPP LTE offers high data rates, mission-critical quality of service, and increased interference resilience."[16] Table 4 covers the proposed lunar surface frequency plan and is generally consistent with the SFCG, CCSDS, IOAG, and NASA LunaNet frameworks.[17]

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[11] *Id.* at considering e.

[12] *Id.* at recognizing b.

[13] *Id.* at considering c.

[14] *Id.* at considering i.

[15] *Id.* at considering j, k.

[16] Spacecraft Onboard Interface Services— High Data Rate 3GPP and Wi-Fi Local Area Communications, Recommended Standard CCSDS 883.0-B-1, Consultative Committee for Space Data Systems at 3-6 (Feb. 2022), https://bit.ly/3Abcb5X.

[17] The current Parsec lunar orbit satellite license application referenced *supra* at note 2 omits certain frequencies identified by these bodies. Lockheed Martin would seek modification of the Parsec authorization before commencing lunar surface-related operations in those frequencies. The modified authority is not necessary, however, for initial operation of the lunar surface assets.

Table 4: Frequency Plan

Band	Proposed Frequency and Service	Link Direction	Space Station Use	U.S. Frequency Allocation Table Compliance
UHF	390-405 MHz space research	space-to-space (lunar orbit-to-lunar surface; lunar surface-to-lunar surface)	LS 1.4 (spacesuits) LS 1.5 (handheld terminals)	No. Waiver request appears in section VI.A.i.
UHF	406-406.1 MHz space research	space-to-space (lunar surface-to-lunar orbit; lunar surface-to-lunar surface)	LS 1.4 (spacesuits) LS 1.5 (handheld terminals)	No. Waiver request appears in section VI.A.i.
UHF	410-420 MHz space research	space-to-space (lunar surface only)	LS 1.4 (spacesuits) LS 1.5 (handheld terminals)	No. Waiver request appears in section VI.A.i.
UHF	435-450 MHz space research	space-to-space (lunar surface-to-lunar orbit; lunar surface-to-lunar surface)	LS 1.4 (spacesuits) LS 1.5 (handheld terminals)	No. Waiver request appears in section VI.A.i.
S-band	2.025-2.11 GHz space research	space-to-space (lunar orbit (Parsec)-to-lunar surface) — Earth-to-space (in transit)	LS 1.1 (robotic landers and payloads) LS 1.2 (lunar mobility vehicles) LS 2.2 (in-situ resource utilization assets) LS 2.3 (expanded application of robotic rovers) LS 3.1 (fission-surface-power support) LS 3.2 (habitation-system support)	Yes. U.S. frequency allocation table permits space research service (space-to-space), and proposed use constitutes space research service, as covered in section I.D.[18]
S-band	2.2-2.29 GHz space research	space-to-space (lunar surface-to-lunar orbit (Parsec)) — space-to-Earth (in transit)	LS 1.1 (robotic landers and payloads) LS 1.2 (lunar mobility vehicles) LS 2.2 (in-situ resource utilization assets) LS 2.3 (expanded application of robotic rovers) LS 3.1 (fission-surface-power support) LS 3.2 (habitation-system support)	No. Waiver request appears in section VI.A.ii.
S-band	2.400-2.480 GHz space research	space-to-space (lunar surface only)	LS 1.1 (robotic landers and payloads) LS 1.2 (lunar mobility vehicles) LS 2.2 (in-situ resource utilization assets) LS 2.3 (expanded application of robotic rovers) LS 3.1 (fission-surface-power support) LS 3.2 (habitation-system support)	Yes. But waiver is requested to the extent necessary in section VI.A.iii.
S-band	2.4835-2.5 GHz radionavigation satellite	space-to-space (lunar orbit (Parsec)-to-lunar surface)	All	No. Waiver request appears in section VI.A.iv.
S-band	2.5035-2.650 GHz space research	space-to-space (lunar surface only)	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system) LS 1.4 (spacesuits) LS 1.5 (handheld terminals) LS 3.1 (fission-surface-power support) LS 2.1 (in-space manufacturing assets) LS 2.3 (expanded application of robotic rovers) LS 3.2 (habitation-system support)	No. Waiver request appears in section VI.A.v.

[18] *See* 47 C.F.R. § 2.106 n.US347.

Band	Proposed Frequency and Service	Link Direction	Space Station Use	U.S. Frequency Allocation Table Compliance
C-band	3.4-3.7 GHz space research	space-to-space (lunar surface only)	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system) LS 1.1 (robotic landers and payloads) LS 1.4 (spacesuits) LS 1.5 (handheld terminals) LS 2.1 (in-space manufacturing assets) LS 2.3 (expanded application of robotic rovers) LS 3.1 (fission-surface-power support) LS 3.2 (habitation-system support)	No. Waiver request appears in section VI.A.v.
C-band	5.01-5.03 GHz radionavigation-satellite	space-to-space (lunar orbit-to-lunar surface)	All	Yes. U.S. frequency allocation table permits radionavigation-satellite service (space-to-space), and proposed use constitutes radionavigation-satellite service, as covered in section I.D.[19]
C-band	5.15-5.35 GHz; 5.47-5.725 GHz; 5.85-5.925 GHz space research	space-to-space (lunar surface only)	LS 1.1 (robotic landers and payloads) LS 1.2 (lunar mobility vehicles) LS 2.2 (in-situ resource utilization assets) LS 2.3 (expanded application of robotic rovers) LS 3.1 (fission-surface-power support) LS 3.2 (habitation-system support)	Yes. But waiver is requested to the extent necessary in section VI.A.iii.
X-band	7.19-7.235 GHz space research	Earth-to-lunar surface — Earth-to-space (in transit)	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system) LS 2.3 (expanded application of robotic rovers) LS 2.1 (in-space manufacturing assets) LS 2.2 (in-situ resource utilization assets) LS 3.2 (habitation-system support)	No. Waiver request appears in section VI.A.ii.
X-band	8.45-8.5 GHz space research	lunar surface-to-Earth — space-to-Earth (in transit)	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system) LS 2.3 (expanded application of robotic rovers) LS 2.1 (in-space manufacturing assets) LS 2.2 (in-situ resource utilization assets) LS 3.2 (habitation-system support)	Yes. U.S. frequency allocation table permits space research service (space-to-Earth), and proposed use constitutes space research service, as covered in section I.D.[20]
Ka-band	22.55-23.15 GHz space research	Earth-to-lunar surface — Earth-to-space (in transit)	LS 1.3 (human landing system) LS 2.1 (in-space manufacturing assets) LS 3.2 (habitation-system support)	Yes. U.S. frequency allocation table permits space research service (Earth-to-space), and proposed use constitutes space research service, as covered in section I.D.[21]
Ka-band	23.15-23.55 GHz inter-satellite	space-to-space (lunar orbit (Parsec)-to-lunar surface)	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system)	Yes. U.S. frequency allocation table permits inter-satellite service, and proposed use constitutes inter-satellite service, as covered in

[19] *See id.* 2.106.

[20] *See id.*

[21] *See id.*

Band	Proposed Frequency and Service	Link Direction	Space Station Use	U.S. Frequency Allocation Table Compliance
			LS 1.4 (spacesuits) LS 1.5 (handheld terminals) LS 2.3 (expanded application of robotic rovers) LS 2.1 (in-space manufacturing assets) LS 2.2 (in-situ resource utilization assets) LS 3.2 (habitation-system support)	section I.D.[22]
Ka-band	25.5-27.0 GHz space research	Lunar surface-to-Earth – space-to-Earth (in transit)	LS 1.3 (human landing system) LS 2.1 (in-space manufacturing assets) LS 3.2 (habitation-system support)	Yes. U.S. frequency allocation table permits space research service (space-to-Earth), and proposed use constitutes space research service, as covered in section I.D.[23]
Ka-band	27.0-27.5 GHz inter-satellite	space-to-space (lunar surface-to-lunar orbit (Parsec))	LS 1.1 (robotic landers and payloads) LS 1.3 (human landing system) LS 1.4 (spacesuits) LS 1.5 (handheld terminals) LS 2.3 (expanded application of robotic rovers) LS 2.1 (in-space manufacturing assets) LS 2.2 (in-situ resource utilization assets) LS 3.2 (habitation-system support)	Yes. U.S. frequency allocation table permits inter-satellite service, and proposed use constitutes inter-satellite service, as covered in section I.D.[24]

[22] *See id*.

[23] *See id*.

[24] *See id*.

Because the proposed space research service and inter-satellite service frequencies host shared federal and non-federal allocations, Lockheed Martin recognizes the need to pre-coordinate the use of the identified spectrum bands and will complete the process, as necessary.

C. Schedule S Sample Use Cases

The attached Schedule S is organized to address the payload characteristics of each of the space stations identified and specifies all radiofrequency characteristics. Enveloping use cases were developed for each frequency band to ensure radiofrequency parameters for Schedule S are realistic for the use cases of each band and establish limits that will apply to all users that will conduct their operations under this authorization. As this filing is for authority for a diverse set of services, the payload and bus description for each differs.

UHF terminals. These terminals would be space stations using 390-405 MHz and 435-450 MHz bands, consisting of a small size, weight, and power ("SWaP") backup radio (potentially just a card integrated into a handheld device or small robotic instrument). These terminals have a moderate range for surface-to-surface communication at less than 2 Msps or low ksps to and from lunar orbit. Terminals are equipped with omni (mobile phone or tablet style) antennas with small (2 W or less) radiofrequency amplifiers.

UHF emergency beacons. These beacons would include a small SWaP radio or card with an omni directional antenna capable of sending very low data rates from the surface to lunar orbit for emergency needs in the 406-406.1 MHz band. Terminals have less than 1 W radiofrequency amplifiers and transmit at 250 to 1000 bps. These payloads have no receive capability.

Surface-Only UHF terminals. Operating in the 410-420 MHz range with transmit and receive capability, these terminals are similar to the UHF terminal but are limited to surface-only transmission. Expected uses would be handheld or small local robotic payloads with less than 1 W output and an omni directional antenna for local communications of less than 2 Msps.

Robotic science space stations. Space stations using the 2.025-2.11 GHz and 2.2-2.29 GHz bands would be robotic landers that might traditionally send signals to and from Earth, but in the context of this application would leverage Parsec and other space relay assets. These space stations would be less than 2000 kg and capable of landing themselves on the Moon's surface and potentially deploying multiple independent payloads. Initial space stations in this class would only have power storage capability to survive during the lunar day, but within 3-5 years, the expectation is to start seeing longer duration missions. These space stations will largely be stationary; however, some may have limited roving capability or may deploy small, life-limited rovers as secondary payloads. The payloads on these space stations will utilize 2.025-2.11 GHz as a receive frequency from orbit and transmit their data on the 2.2-2.29 GHz channel. These space stations will require more directive antennas reaching up to 18-20 dBi of gain, with larger radiofrequency amplifiers, capable of outputting up to 20 W. To support navigation these space stations may also be equipped with a 2.5 GHz Lunar Augmented Navigation System ("LANS") signal. These receive-only terminals will operate with a noise floor around -140 dB (Pt) and receive LANS signals from lunar orbiting satellites.

Base station payloads. Larger science or base stations will enable payloads that will be deployed in close range to a human base station or a robotic lander or rover such that the data generated will be transmitted from the payload to the base station. These payloads will include a multi-band surface-to-surface radio to provide high data rate links back to the base station as well as a LANS receiver in the cases where the payload needs navigation data. The multi-band radios will operate in S- and C-band (2.4-2.48 GHz, 2.5035-2.65 GHz, and 3.4-3.7 GHz) with rates from 30 Mbps in the lowest band up to 100 Mbps in the higher bands. These bands will support video, voice, and data between the payload and the base station. The 5.01-5.03 GHz band may be used as an alternate band for the LANS navigation signal.

Science research space stations. Science space stations requiring the highest data throughput will utilize X- and Ka-band links to transmit data to Earth and also to lunar orbit space stations for further transmissions. These space stations could be robotic or associated with human landing sites to support voice, video, and data transmission. These space stations will be the most varied with sizes ranging from smaller (less than 1000 kg) robotic exploration space stations carrying science payloads to larger (greater than 2000 kg) multi-year mobile missions. These space stations will have larger (1 m diameter) gimballed antennas capable of transmitting up to 100 Mbps at Ka-band and receiving up to 40 Mbps. Larger (20 W) radiofrequency amplifiers will be part of the communications system to support the higher data rates. These space stations will use bandwidth efficient LDPC 7/8 encoding with QPSK or oQPSK modulations when transmitting and receiving in the 10s of Mbps. The X-band portions of the payload will be restricted to transmitting telemetry, tracking, and command ("TT&C") signals to and from Earth, and these signals will be lower rates (less than 2 Mbps) with similar sized antennas and solid state power amplifiers generating 30 dBi of gain with 20 W radiofrequency output power.

D. Service Classifications

The various lunar surface space stations would deliver space research service and inter-satellite service and receive radionavigation-satellite service data, as allocated in the international and U.S. frequency allocation tables, except as indicated in the waiver requests (section VI.A).

Space research service. The space research service covers space stations that participate in "scientific or technological research purposes."[25] The International Telecommunication Union ("ITU") Space Research Handbook further explains

> [t]he space research technology programmes focus on development and validation in space of advanced technologies needed for: – fabrication and assembly of space structures; – construction of electro/mechanical systems; – the study of fluid behaviour and transport phenomena; – robotics for structure assembly and on-orbit satellite servicing; – space processing and manufacturing techniques.
>
> In particular, the study of the micro-gravity environment of space for scientific and commercial purposes develops and enhances the ability of [humans] to live and work in space for extended periods of time, and increases our understanding of materials science and biomedical sciences.[26]

The Lockheed Martin lunar surface assets would support lunar exploration and experiments for scientific and commercial un-crewed and crewed missions, as identified in Table 1, Table 2, and Table 3. As a result, the lunar surface assets qualify as space research service.

Inter-satellite service. The inter-satellite service provides links between space stations.[27] The FCC inter-satellite service rule provides that "[a]ny satellite communicating with other space stations may use frequencies in the inter-satellite service as indicated in [the international and U.S. frequency allocation tables]."[28] The underlying FCC decision clarifies this rule applies to "any space station communicating with another space station using frequencies in the [inter-satellite service] bands."[29] The Commission defines "space station" as "a station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere."[30]

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[25] *See* ITU RR No. 1.55. ITU jurisdiction over use of radio spectrum stemming from lunar activities is well established. *See, e.g.*, ITU RR Article 22, Section V; Rec. ITU-R RA.479-5 (protection of frequencies for radioastronomical measurements in the shielded zone of the Moon). *See generally infra* § VII.

[26] ITU Handbook on Space Research Communication, at 1 (2014), https://bit.ly/2NLEU5z.

[27] *See* ITU RR No. 1.22.

[28] 47 C.F.R. § 25.279(a).

[29] *The Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band*, Report and Order, 15 FCC Rcd 16127 ¶ 88 (2000).

[30] 47 C.F.R. § 25.103.

Given this clear, existing inter-satellite service framework, lunar orbiting space stations may communicate with lunar surface space stations and lunar surface space stations may communicate with each other in the 23.15-23.55 GHz and 27.0-27.5 GHz bands without any FCC rule waiver for two reasons. *First*, both the international and U.S. frequency allocation tables authorize the inter-satellite service in these bands.[31] *Second*, the Parsec satellites in the Moon's orbit and the space stations on the Moon would clearly operate beyond the Earth's atmosphere (approximately 340,000 km from the geostationary Earth-orbit arc and 380,000 km from low-Earth orbits and the Earth's surface). Both the Parsec satellites and lunar surface space stations, therefore, constitute "space stations" permitted to use the pertinent frequencies as inter-satellite service.

Radionavigation-satellite service. The radionavigation-satellite service covers space stations providing lunar surface position determination solutions and lunar environment messaging – space weather alerts and collision avoidance messages, among other things.[32] The Lockheed Martin lunar surface assets would receive signals from lunar orbit radionavigation satellites consistent with NASA requirements and, therefore, are permitted to use the pertinent frequencies as radionavigation-satellite service. The radionavigation-satellite service provider would need to secure necessary regulatory approvals before the Lockheed Martin lunar surface assets received any signals in this spectrum.[33]

E. Terrestrial Frequency Protection

Lunar surface assets would not impede Earth surface operations. For the 3650-3700 MHz, 22.55-23.55 GHz, and 25.5-27.5 GHz bands, the FCC rules impose space station power flux-density ("PFD") limits.[34] For all other proposed frequencies, the FCC rules do not impose PFD limits. In their absence, Lockheed Martin will satisfy relevant ITU RR Article 21 PFD limits for co-frequency space radiocommunications, as outlined in Table 5, or where ITU RR are silent, ensure harmful interference would not occur, also as outlined in Table 5.

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[31] The international frequency allocation table offers primary inter-satellite service allocations in the 23.15-23.55 GHz and 27.0-27.5 GHz bands, and the U.S. frequency allocation table offers a primary non-federal inter-satellite service allocation in the 23.15-23.55 GHz band and a secondary non-federal allocation in the 27.0-27.5 GHz band. *See* 47 C.F.R. § 2.106.

[32] *See* ITU RR Nos. 1.8, 1.41, 1.43.

[33] If the Parsec satellites provide lunar-based radionavigation-satellite service, Lockheed Martin will seek the necessary authority.

[34] *See* 47 C.F.R. § 25.208(a), (c), (p).

Table 5: PFD Compliance

		Limit in dB(W/m²) for angles of arrival (δ) above the horizontal plane				
Band	**Proposed Frequency and Service**	**0°-5°**	**5°-25°**	**25°-90°**	**Reference Bandwidth**	**Compliance**
UHF	390-405 MHz space research	N/A	N/A	N/A	N/A	See Note 1.
UHF	406-406.1 MHz space research	N/A	N/A	N/A	N/A	See Note 1.
UHF	410-420 MHz space research	N/A	N/A	N/A	N/A	See Note 1.
UHF	435-450 MHz space research	N/A	N/A	N/A	N/A	See Note 1.
S-band	2.025-2.11 GHz space research	−154[35]	−154 + 0.5(δ−5)[36]	−144[37]	4 kilohertz	See Note 2.
S-band	2.2-2.29 GHz space research					
S-band	2.400-2.480 GHz space research	N/A	N/A	N/A	N/A	See Note 1.
S-band	2.4835-2.5 GHz radionavigation satellite	N/A	N/A	N/A	N/A	See Note 1.

[35] *See* ITU RR 21.16.3 ("These power flux-density values are derived on the basis of protecting the fixed service using line-of-sight techniques. Where a fixed service using tropospheric scatter operates in the bands listed in the first column and there is insufficient frequency separation, there must be sufficient angular separation between the direction to the space station and the direction of maximum radiation of the antenna of the receiving station of the fixed service using tropospheric scatter, in order to ensure that the interference power at the receiver input of the fixed-service station does not exceed −168 dBW in any 4 kHz band.").

[36] *See id.*

[37] *See id.*

		Limit in dB(W/m²) for angles of arrival (δ) above the horizontal plane				
Band	**Proposed Frequency and Service**	**0°-5°**	**5°-25°**	**25°-90°**	**Reference Bandwidth**	**Compliance**
S-band	2.5035-2.650 GHz space research	−136[38]	$-136 + 11/20(\delta - 5)$[39]	−125[40]	1 megahertz	See Note 2.
C-band	3.4-3.7 GHz[41] space research	−152	$-152 + 0.5(\delta-5)$	−142	4 kilohertz	See Note 2.
C-band	5.01-5.03 GHz radionavigation-satellite	N/A	N/A	N/A	N/A	See Note 1.
C-band	5.15-5.35 GHz[42] space research	−164			4 kilohertz	See Note 1 and 2.
C-band	5.47-5.725 GHz[43] space research	−152	$-152 + 0.5(\delta - 5)$	−142	4 kilohertz	See Note 1 and 2.
C-band	5.85-5.925 GHz space research	N/A	N/A	N/A	N/A	See Note 1.
X-band	7.19-7.235 GHz space research	N/A	N/A	N/A	N/A	See Note 1.
X-band	8.45-8.5 GHz space research	−150	$-150 + 0.5(\delta - 5)$	−140	4 kilohertz	See Note 3.
Ka-band	22.55-23.15 GHz	−115	$-115 + 0.5(\delta - 5)$	−105	1 megahertz	See Note 3.

[38] *See* ITU RR No. 21.16.3A (“Resolution 903 (Rev.WRC-19) shall apply. (WRC-19)”).

[39] *See id.*

[40] *See id.*

[41] This limit applies to GSO only.

[42] This limit applies for the 5150-5216 MHz band only.

[43] This limit applies for the 5670-5725 MHz band only.

		Limit in dB(W/m^2) for angles of arrival (δ) above the horizontal plane				
Band	**Proposed Frequency and Service**	**0°-5°**	**5°-25°**	**25°-90°**	**Reference Bandwidth**	**Compliance**
	space research					
Ka-band	23.15-23.55 GHz inter-satellite					See Note 2.
Ka-band	25.5-27.0 GHz space research					See Note 3.
Ka-band	27.0-27.5 GHz inter-satellite					See Note 2.

<u>Note 1</u>: No PFD limits apply. Despite no relevant rules applying, the space stations will not pose interference to terrestrial assets for at least two reasons. *First*, operations would not commence until the space stations reach the lunar surface (approximately 380,000 km from low-Earth orbits and the Earth's surface). *Second*, when functioning, lunar surface assets have low power, directional antennas. These antennas are primarily supporting surface-to-surface or lunar orbit-and-surface communications, for which (i) only potential sidelobe signals escape past the Moon and (ii) greater than 211 dB free space attenuation applies for any such signals.

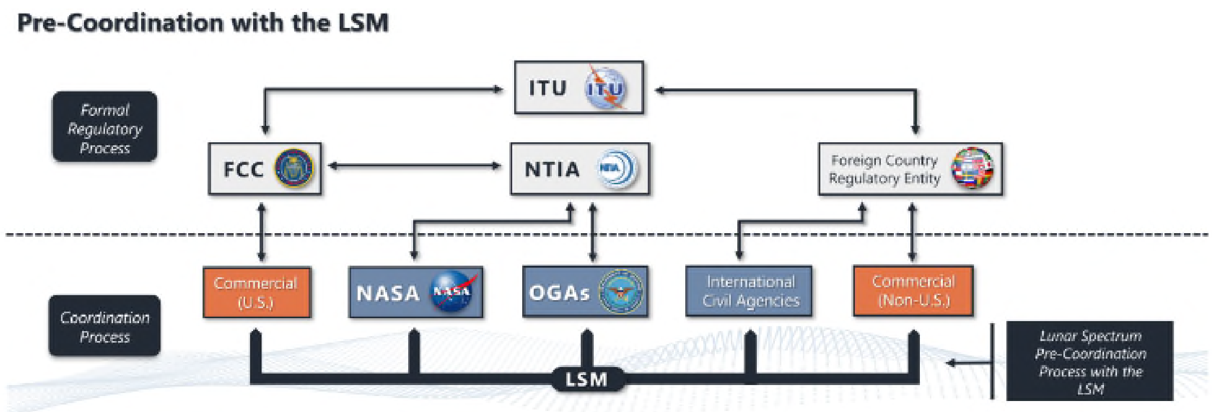
<u>Note 2</u>: The space stations will satisfy the ITU PFD limits for at least two reasons. *First*, operations would not commence until the space stations reach the lunar surface (approximately 380,000 km from low-Earth orbits and the Earth's surface). *Second*, when functioning, lunar surface assets have low power, directional antennas. These antennas are primarily supporting surface-to-surface or lunar orbit-and-surface communications, for which (i) only potential sidelobe signals escape past the Moon and (ii) greater than 211 dB free space attenuation applies for any such signals.

<u>Note 3</u>: The space stations will satisfy the ITU PFD limits for at least two reasons. *First*, for in-transit operations (between low-Earth orbit and lunar surface), the space stations will use low-gain and low-power antennas until [--] km altitude (X-band) and [--] km altitude (Ka-band) above the Earth's surface to ensure compliance with the ITU PFD limits. No other frequencies support Earth-centric operations. *Second*, for lunar surface operations, lunar surface assets have low power, directional antennas. These antennas are primarily supporting surface-to-surface or lunar orbit-and-surface communications, for which (i) only potential sidelobe signals escape past the Moon and (ii) greater than 211 dB free space attenuation applies for any such signals.

F. Space Frequency Protection

Lockheed Martin will coordinate all lunar-related frequency uses with the Lunar Spectrum Manager using the Lunar Spectrum Management Portal ("LSMP").[44] As depicted in Figure 1, the LSMP "serves as a centralized focal point in the lunar region for advanced spectrum planning and facilitating mission system development and pre-coordination to mitigate potential interference for government, private sector, and international entities to operate joint and/or independent missions."[45]

Figure 1: Lunar Spectrum Management Process



As of February 2023, the LSMP has summarized information for over 55 missions, including the Parsec mission.[46]

G. Ground Segment

The lunar surface space stations would use third-party Earth stations to communicate on the requested Earth-centric frequencies, which shall be compatible with NASA's Deep Space Network for additional Earth station options and dedicated support for NASA missions. Only when the lunar surface space stations are within line of sight of any authorized Earth station would 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 would be coordinated and authorized to operate at the defined

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[44] *See About the Lunar Spectrum Manager*, NASA, https://bit.ly/3HlEctl (last updated June 24, 2022).

[45] *NASA Lunar Spectrum Management: Enabling and Protecting Lunar Science & Exploration*, NASA (June 7-9, 2022), https://go.nasa.gov/3PlxjKV. This presentation outlines the pre-coordination process and describes the benefits of the LSMP approach.

[46] *See Lunar Mission Landscape*, NASA, https://bit.ly/3DsgCtM (last updated Jan. 18, 2023).

frequencies by the applicable jurisdiction. Further, Lockheed Martin will safeguard its transmitting station and satellite commands from unauthorized access and use.[47]

Table 6 specifies initial Earth station locations. Should additional Earth stations become necessary, Lockheed Martin requests to coordinate the sites and notify the Commission of coordination completion instead of seeking a license modification.[48]

Table 6: Lunar Surface Space Stations' Earth Stations

Location	Coordinates
Goonhilly, United Kingdom	50.0482° N, 5.1810° W
Troll, Antarctica	72.0022° S, 2.0575° E
Punta Arenas, Chile	70.85° S, 52.9333° E
Svalbard, Norway	78.231° N, 15.389° E
Santiago, Chile	70.67° S, 33.13° E
Esrange, Sweden	67.53° N, 21.04° E
South Point, Hawaii, United States	19.02° N, 155.66° W
Dongara, Australia	29.05° S, 115.20° E

On average over a lunar month, the affiliated Earth stations can provide 100% coverage of the non-shielded Moon side (where at least one station has visibility). The Moon would be simultaneously visible from at least two stations greater than 99% of the time.

H. Telemetry, Tracking, and Command Segment

The TT&C frequencies will depend on whether the lunar surface space stations are in transit from Earth orbit to the lunar surface (scenario 1) or are operating on the lunar surface (scenario 2). For scenario 1, X- and Ka-band frequencies will support TT&C activities. For scenario 2, each lunar surface's space station's service link frequency or, if available, the inter-satellite service link frequencies will support TT&C activities.

II. CUSTOMERS AND BUSINESS PLAN

Lockheed Martin is investing in the development of lunar infrastructure elements under a services-based business model. The first of these services is a lunar communications relay network called Parsec, which will be owned and operated by Lockheed Martin to provide commercial relay services to a variety of customers. The lunar surface space stations (commonly referred to as terminals) that are the subject of this application will

[47] *See* 47 C.F.R. § 25.271(d).

[48] *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).

interface with the Parsec communications network to provide end-to-end connectivity between Earth and the lunar region.

Lockheed Martin anticipates that the initial mission would provide services primarily to NASA. The mission would expand to include other U.S. entities (commercial, educational, governmental, and research), international space agencies, and other national governments. Various international space agencies and governments as well as commercial entities have expressed a need for these services, which are enabled by the lunar surface space stations in coordination with the Parsec network. Commercial customers could include commercial lunar lander companies, commercial rover companies, and scientific institutions.

Currently, every mission brings its own dedicated standalone communications solution. By providing lunar communications infrastructure as a service, customers can focus on their mission, instead of communications, thereby simplifying and improving their links, and enabling exploration of previously inaccessible areas. A relay service and the associated lunar surface terminals allow for exploration of the lunar far side, permanently shadowed regions, and the lunar south pole. This comprehensive service framework is critical to supporting a growing, robust lunar economy where missions will become mobile and their line of sight will change over time; in time, it will also support the buildout of other critical surface infrastructure like landings, habitats, and power stations.

Lunar surface space stations will serve as user terminals for access to the communications network. Users will purchase or license the terminal from Lockheed Martin, coordinate mission design to ensure compliance to regulatory requirements, and plan their mission in collaboration with Lockheed Martin. Users would own and operate their own missions in the lunar regime, and their data will be transported through the communications network.

The network is expected to be scalable and flexible to meet the demand of the lunar market as it grows. This flexibility will allow for in-space configurability to modify user links as required, ensuring maximum usability by customers.

Communications services would include end-to-end services, receiving a radiofrequency signal from a user on the lunar surface or lunar orbit, relaying the signal through the Parsec lunar orbit space stations back to Earth, and backhauling the signal to the user mission operations center. The service transports data between the lunar environment and Earth.

Customers upload space station commands to the Parsec mission operations center through the secure customer API, and the network delivers the commands to the vehicle on the lunar surface. Space station data (telemetry, health, and mission data) are transmitted from the user vehicle up to the Parsec relay satellite, where the data are transmitted back to Earth and made available through the same customer portal. Customer data are end-point encrypted.

The lunar surface service model resembles the earth station service model. On Earth, one entity will secure blanket license earth stations. That entity may use the earth stations itself; or it may make the stations available to third-party entities, with contractual provisions obligating the third party to satisfy all relevant FCC authorization conditions and rules. The same will apply for third parties using lunar surface space stations authorized to Lockheed Martin under this application. Lockheed Martin will have a cessation capability for its or third party lunar surface assets under the currently sought authorization.[49]

For the proposed lunar communications network, customers will purchase time in a similar manner to how they purchase time for an Earth station under a service agreement. For NASA customers, services are offered as either nominal or critical services: nominal services include telemetry and commanding; critical services include contingency and emergency operations for users experiencing anomalies that would threaten overall mission lifetime or potentially cause loss of mission. These services are modeled to support NASA's Near Space Network architecture.

Outside of NASA missions, customers may purchase time on the proximity links (between lunar orbit space stations and lunar user space stations) and may purchase time as either dedicated (lunar days to support mission) or hourly (up to a percentage of the overflight period of the user). It is envisioned that users will purchase services to support the entire mission duration from launch and cruise through end of life. Customers can utilize the user terminals (lunar surface space stations) as their communications equipment for their mission.

III. MISSION DESCRIPTION

Following is information on the lunar surface space stations' launch, transit, and lunar surface timing and operational areas.

Launch. The first lunar surface space station launch is anticipated to occur in early 2024 to support NASA CLPS missions.[50] Launches would be from various launch facilities on either a dedicated small launch vehicle or rideshared large launch vehicle.

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[49] *See* 47 C.F.R. § 25.207.

[50] *See NASA Lunar Spectrum Management: Enabling and Protecting Lunar Science & Exploration*, NASA, at 4 (June 7-9, 2022), https://go.nasa.gov/3PlxjKV; *see, e.g.*, *Moon to Mars*, Lockheed Martin (2019), https://lmt.co/3uKhDJw.

Transit. Each lunar mission will have a transit phase between the Earth and Moon. This transit can take a variety of forms and trajectories that span between 5 days or several months in duration. During this transit phase, these space missions will communicate directly with Earth and may utilize lunar communications services (*i.e.*, Parsec).

Lunar surface. To determine lunar surface operational locations, lunar operators would maximize available data to match mission objectives with the use of other location resources, including the latest unified geologic map of the moon from the United States Geological Survey; the selenocentric reference frame described in the NASA Lunar Reference Frame Standard; NASA recommendations on protecting and preserving the historic and scientific value of U.S. government lunar artifacts; and position data provided during coordination with third parties operating lunar surface assets. Most missions will span hours to days given the limited energy resources currently available.

IV. PUBLIC INTEREST CONSIDERATIONS

The U.S. Congress has declared, and it has been implemented into law, that "that the general welfare of the United States requires that the Administration seek and encourage, to the maximum extent possible, the fullest commercial use of space."[51] As part of this policy, the law directs that "[t]he aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives[, including the] preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere."[52] This application directly serves these goals and thus also directly serves the public interest.

Quality lunar communications services are critical to U.S. leadership in the continued expansion of lunar exploration and economic development. Over 100 lunar missions are planned in the next decade;[53] many are funded by new market entrants with unique and

[51] 51 U.S.C. § 20102(c).

[52] *Id.* § 20102(d), (d)(5).

[53] Luxembourg's space program is reportedly partnering with NASA on Moon mining operations to enable inhabitants of NASA's future Artemis lunar base camp to search for resources and process them into necessary materials. *See Luxembourg space programme to work with Nasa on moon mining*, Financial Times, https://on.ft.com/3GQMKtc (Feb. 16, 2021). An Italian company, Argotec S.r.l., is planning a microsatellite constellation to "provide constant access to real-time data for users in the lunar environment." *Andromeda: A new constellation among the constellations*, Argotec S.r.l., https://bit.ly/3vSFF4U (last viewed Feb. 18, 2023). An Australian-based lunar exploration mission called the Seven Sisters Program plans to

forward-leaning missions for lunar science and exploration. Programs like the NASA CLPS[54] and Artemis rideshare opportunities are enabling a new class of space pursuits for start-up companies, university labs, and large aerospace prime contractors alike.

Every mission requires a communications capability to transport its data between the space station and Earth. Absent a commercial lunar communications network, each mission needs to provide its own end-to-end communications, including specialized hardware. The Parsec network eliminates this need by providing access to a robust and reliable communications infrastructure based on NASA and internationally vetted documentation.

The lunar surface space stations specified in this application will act as pre-defined user terminals capable of connecting with the Parsec communications infrastructure. Initial users will be robotic landers and mobile platforms on the lunar surface and followed shortly thereafter by human missions that include handheld and vehicle-based terminals. These terminals will provide immediate and reliable connections with the lunar communications network infrastructure, enabling missions to securely send and receive data. Having a licensed communications infrastructure in place will facilitate space exploration by allowing missions to focus on their core scientific and exploration goals without having to expend resources on data transport. The Parsec network will reduce the cost of and increase access to the Moon for many new space-focused organizations.

The type of lunar communications infrastructure envisaged is critical to ensure the U.S. position as a global leader for lunar exploration and development.[55] However, the lunar

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use nanosatellites and sensors to act as a compliment to NASA's Artemis Program. *See Australian Lunar Exploration Mission Unveiled by Fleet Space Technologies*, SpaceAustralia.com (Jan. 11, 2021), https://bit.ly/3VY1GKp.

[54] NASA's CLPS initiative aims to "allow rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration or commercial development of the Moon." *Commercial Lunar Payload Services Overview*, National Aeronautics and Space Administration, https://go.nasa.gov/3i4Uf6s (last updated Jan. 9, 2023).

[55] Development of space resources is a high policy priority the U.S. government enacted into law as noted above. For example, in November 2022, the National Science and Technology Council issued a "National Cislunar Science and Technology Strategy," which sets forth as one of four objectives to "[i]mplement Cislunar communications and PNT [positioning, navigation, and timing] capabilities with scalable and interoperable approaches." Cislunar Technology Strategy Interagency Working Group, *National Cislunar Science & Technology Strategy*, National Science & Technology Council, at 5 (Nov. 2022), https://bit.ly/3Xju5Mk. Earlier, in December 2021, the White House released the "United States Space Priorities Framework," which notes that "U.S. commercial space activities are on the cutting edge of space

surface space stations specified in this application would benefit not only U.S. interests but also international governments and various commercial users, thus fostering global cooperation in the development of a lunar operational framework. Most important, this infrastructure would establish American leadership in lunar supply missions, ensure successful landings by crewed space stations, increase crewed-mission safety by providing real-time communications, and deliver data from lunar experiments to Earth in a timely way.

This application represents an important step in the new race to the Moon and presents an opportunity to demonstrate American leadership in lunar exploration and communication. Grant of this application would establish the United States as a global leader in lunar infrastructure and greatly enhance the communications capabilities for missions that would bring unique and valuable scientific and engineering payloads to the lunar surface. The proposed lunar surface space stations will not only help individual missions achieve their full capabilities but will also provide economic benefits by stimulating market growth, expanding the space industrial base, and creating many new American jobs.

V. SPACE DEBRIS AND HUMAN RADIOFREQUENCY EXPOSURE MITIGATION STRATEGY

The lunar surface space stations satisfy relevant current FCC regulations and NASA standards, as covered in Attachment A (Space Debris Mitigation Plan) and Attachment B (Human Radiofrequency Exposure Mitigation Plan)Attachment B (Human Radiofrequency Exposure Mitigation Plan). Further, Lockheed Martin is participating in the Lunar Surface Innovation Consortium[56] and Moon Village Association Global Expert Group on Sustainable Lunar Activities,[57] among other leading standards-development efforts. As part of these activities, Lockheed Martin commits to monitoring and satisfying relevant future lunar debris and human radiofrequency exposure mitigation standards.

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technology, space applications, and space-enabled services." *United States Space Priorities Framework*, The White House, at 5 (Dec. 2022), https://bit.ly/3HahoOf. As part of that leadership, the Priorities Framework pledges to "advance a robust cislunar ecosystem." *Id*.

[56] The Lunar Surface Innovation Consortium is a collaborative effort between the NASA Space Technology Mission Directorate and The Johns Hopkins University Applied Physics Laboratory. *Lunar Surface Innovation Consortium*, https://lsic.jhuapl.edu/ (last visited Feb. 18, 2022).

[57] *See What is the GEGSLA?*, Moon Village Association, https://bit.ly/3dXHLuH (last viewed Feb. 18, 2023).

VI. WAIVER REQUESTS

For the proposed lunar and cislunar services, this section specifies waivers required of regulations that are not suitable for non-Earth-centric operations but instead apply to a different context than the services provided in this application.

The Commission may waive rule compliance if "good cause" exists.[58] Waiver is appropriate where "special circumstances warrant a deviation from the general rule and such deviation would serve the public interest" better than strict adherence to the rule.[59] 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.[60] Potential hardship, equity, or policy implementation factors may influence the waiver decision.[61] 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."[62] Good cause exists to waive the following rules to the extent necessary to consider and grant the application.

Many of the rule sections noted below were adopted for Earth-centric applications and services and should not apply to a novel lunar and cislunar service structure based on a complex, multi-faceted communications system. This application presents substantial public interest benefits by fostering U.S. leadership in space while providing a unique, advanced technical platform for space services. As such, each of the waiver requests in this section should not be reviewed in isolation but instead should be considered against the backdrop of the overriding public interest benefits that grant of this application would provide and, in particular, the U.S. policy towards use of space.

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[58] *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).

[59] *Northeast Cellular*, 897 F.2d at 1166.

[60] *WAIT Radio*, 418 F.2d at 1157.

[61] *Id.* at 1159.

[62] *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).

A. 47 C.F.R. §§ 2.106, 25.202(b) (U.S. Frequency Allocation Table)

The U.S. frequency allocation table and supporting FCC rules omit allocations for some frequencies proposed in this application. The following sub-sections explain why approving each, on a non-protected basis, would serve the public interest while not posing interference concerns to existing allocated services. Should the ITU or FCC adopt permanent allocations, Lockheed Martin requests adoption of the interference protections for each relevant lunar surface space station without further amendment of this application or, if the application is approved, modification of the license.

i. 390-405 MHz, 406-406.1 MHz, 410-420 MHz, and 435-450 MHz

In the 390-405 MHz, 406-406.1 MHz, 410-420 MHz, and 435-450 MHz bands, no non-federal space research service (space-to-space) allocation exists.[63] The proposed non-conforming use nevertheless would not pose interference risk. The spacesuits and handhelds would primarily rely on Wi-Fi frequencies (2.4 GHz and 5 GHz bands) when communicating with each other. This equipment would only enlist the 410-420 MHz band for backup communications (medical information transmittal, for example) and 390-405 MHz, 406-406.1 MHz, and 435-450 MHz bands for emergency communications.

410-420 MHz. The proposed use would generally mirror the international frequency allocation table already permitting some space research service (space-to-space).[64]

390-405 MHz, 406-406.1 MHz, and 435-450 MHz. The proposed use would occur only when the Wi-Fi and primary links are unavailable.

Both activities and the bands considered are consistent with NASA's existing spacesuit and handheld communications architecture[65] and planned system designs generally following the SFCG, CCSDS, IOAG, and LunaNet frequency plans and ITU WRC future agenda item proposals.[66]

Lunar surface protection. To ensure that co-frequency, lunar-surface systems experience no service degradation, Lockheed Martin would complete coordination with the relevant spectrum users using the NASA LSMP. Further, Lockheed Martin has experience coordinating with the NASA Jet Propulsion Laboratory ("JPL") and Goddard Space Flight Center ("Goddard"), European Space Agency ("ESA"), Laboratory for Atmospheric and

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[63] *See generally* 47 C.F.R. § 2.106.

[64] *See id*. n.5.268.

[65] *See, e.g.*, NASA Extravehicular Mobility Unit (EMU), LSS/SSA Data Book, rev V, JSC-E-DAA-TN55224 § 2.1.1 (Sept. 2017), https://bit.ly/3Sz90fD.

[66] *See supra* § I.B.

Space Physics ("LASP"), and United Arab Emirates ("UAE") Space Agency, and Indian Space Research Organisation ("ISRO") in other mission contexts.

Lunar radio astronomy protection. To ensure protection of the far-side radio quiet zone, assets utilizing these sub-2 GHz frequencies will be required to coordinate and deconflict activities on the far side of the Moon with any affected instruments based on time and duration of use. These sub-2 GHz frequencies are necessary for a variety of human use-cases on the Moon's surface, and their use must be enabled during periods of human presence on the far side.

Earth surface protection. Use of these frequencies on the lunar surface would not impede Earth surface operations given space path loss and other radiofrequency attenuating factors, as discussed. The non-interference risk, coupled with the needs for interoperability and commitment to coordinate, support the requested rule relief.

ii. 2.2-2.29 GHz and 7.19-7.235 GHz

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.[67] The proposed lunar surface space stations would communicate with Parsec, a non-TDRSS asset, and would use the entire 2200-2290 MHz band. Permitting the nonconforming operations is justified for the following reasons.

Interference, if any, would prove imperceptible and would never rise to the level of harmful interference. In the 2200-2290 MHz band, the lunar surface space stations would only communicate with Moon-orbiting assets, approximately 340,000 km from the geostationary arc and 380,000 km from low-Earth orbits and the Earth surface. The large separation distance ensures only faint signals enter Earth orbits and helps satisfy the relevant power-flux density limit at the Earth's surface.[68] To further lessen interference risk, the use of filtered BPSK and/or QPSK modulation and channel coding would reduce power spectral density, as recommended by the SFCG, which includes U.S. federal agencies.[69] Although near-zero interference risk remains after implementing these operational practices, Lockheed Martin would coordinate the proposed frequencies to eliminate all potential risk.

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[67] *See* 47 C.F.R. § 2.106 n.US303.

[68] *See* ITU RR Table 21-4.

[69] *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.

The requested 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 for applications authorized by the United States would reduce American leadership in lunar exploration if other administrations do not impose similar constraints on their commercial operators.

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.[70] Lockheed Martin proposes to deliver space research service using this band for a non-deep space mission.[71] Permitting the non-conforming operations is justified for the following reasons.

Similar to the 2200-2290 MHz band, no risk of harmful interference exists from the proposed operations to the primary frequency users in the 7190-7235 MHz band. The limited number of earth stations using this spectrum would transmit to the lunar surface space stations only when in line of sight for short duty cycles. To ensure co-frequency federal systems experience no service degradation, Lockheed Martin would complete coordination with the relevant spectrum users.

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 for applications authorized by the United States would reduce American leadership in lunar exploration if other administrations do not impose similar constraints on their commercial operators.

iii. 2.400-2.8 GHz, 5.150-5.350 GHz, 5.470-5.725 GHz, and 5.850-5.925 GHz

In the 2.400-2.8 GHz, 5.150-5.350 GHz, 5.470-5.725 GHz, and 5.850-5.925 GHz bands, RLANs may operate unlicensed when satisfying the relevant FCC rules on equipment

[70] *See* 47 C.F.R. § 2.106 n.5.460.

[71] 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 lunar surface space stations are not deep space missions because they would operate approximately 385,000 km from the Earth's surface (approximately 3.85×10^5, for example) to support lunar communications or data storage.

authorization and radiofrequency interference and exposure.[72] In addition to terrestrial RLAN use cases, the Commission has authorized unlicensed frequencies for air-to-ground activities.[73] The lunar space stations would communicate via short range conventional Wi-Fi 802.11ac, classified under U-NII, and appear exempt from licensing requirements similar to the RLAN and air-to-ground cases. To the extent necessary, however, Lockheed Martin seeks rule relief because the Commission has observed the FCC unlicensed rules in Part 15 do not "specifically authorize transmissions intended for operations in a space service."[74]

Any interference is improbable. The lunar space stations would operate at lower power levels than conventional Wi-Fi 802.11ac equipment, have a range of only tens or hundreds of meters, and operate only on or near the lunar surface. Further mitigating concerns are space path loss and radiofrequency attenuation factors, as discussed above. Given the non-existent interference risk, globally standardized and adopted Wi-Fi 802.11ac, SFCG, CCSDS, and IOAG standards for the bands; and need for interoperability among lunar surface assets and continued American leadership in lunar exploration, granting the waiver supports the public interest.

iv. 2.4835-2.5 GHz

In the 2.4835-2.5 GHz band, various services may operate in all or portions of the band: mobile-satellite service (space-to-Earth) and radiodetermination-satellite service (space-to-Earth) in 2.4835-2.49 GHz and mobile-satellite service (space-to-Earth), radiodetermination-satellite service (space-to-Earth), fixed service, and mobile service in 2.49-2.5 GHz.[75] The proposed lunar surface assets would only receive geospatial positioning data in this band from lunar orbiting satellites. Lockheed Martin recognizes the radionavigation-satellite service provider would need to secure necessary regulatory approvals before the Lockheed Martin lunar surface assets received any signals in this spectrum. Authorizing such operations should not pose issue given the space path loss and other radiofrequency attenuating factors ensuring the lunar orbit signals do not interfere with Earth orbit or terrestrial signals. Applying rule relief at this phase is in the public interest to make possible hyper precision on-orbit determination of lunar surface assets without disrupting existing or future planned Earth-based services in the band.

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[72] *See* 47 C.F.R. § 2.106; *see, e.g.*, 47 C.F.R. Part 2 Subpart J; §§ 15.245, 15.247, 15.249, 15.407.

[73] *See, e.g.*, Airspan Communications Limited, Equipment Authorization, FCC Identifier O2J-ATGRU (granted Jan. 26, 2022).

[74] *See* Loft Orbital, Stamp Grant, IBFS File No. SAT-LOA-20190807-00072 et al., Condition 5 (granted Oct. 8, 2020).

[75] 47 C.F.R. § 2.106.

v. 2.5035-2.65 GHz and 3.4-3.7 GHz

In the 2.5035-2.65 GHz and 3.4-3.7 GHz bands, terrestrial fixed and mobile service deployments may occur on a primary basis.[76] Use of these frequencies on the lunar surface would not impede Earth surface operations given space path loss and other radiofrequency attenuating factors, as discussed. The CCSDS supports the use of these frequencies, as noted above, for their "large [commercial off-the-shelf] provider base and attendant reliability" for lunar missions.[77] As explained above, these band selections ensure the highest degree of interoperability among all existing and planned communication assets of all participating agencies and companies while meeting various communications requirements and satisfying cost, mass, and performance objectives.[78] Further, SFCG has proposed frequency usage from 2.5035 GHz to 2.655 GHz. To offer additional protection for radio astronomy and other services, Lockheed Martin requests authority from 2.5035 GHz to 2.650 GHz (with the five-megahertz reduction offering further interference mitigation by frequency separation).

B. 47 C.F.R. § 25.112(a)(3) (Defective FCC Applications)

A space station application is unacceptable if it requests authority to operate in frequency bands not allocated internationally for such operations.[79] The Commission has previously waived this rule for applicants that propose to operate on a non-interference basis when no allocation is available.[80] Additionally, in a recently initiated rulemaking, the Commission has tentatively concluded this rule may no longer be justified:

> [w]e believe waiver requests for satellite operations not in conformance with the International Table of Frequency Allocations, with sufficient supportive reasoning, should be considered on their merits rather than being automatically deemed unacceptable for filing as under current rules. [As the Commission concluded in the context of small satellites, we believe there are some cases in which a waiver of the Table of Frequency Allocations is warranted to permit operations not in

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[76] *See* 47 C.F.R. § 2.106.

[77] Spacecraft Onboard Interface Services— High Data Rate 3GPP and Wi-Fi Local Area Communications, Recommended Standard CCSDS 883.0-B-1, Consultative Committee for Space Data Systems at 3-6 (Feb. 2022), https://bit.ly/3Abcb5X.

[78] *See* Communication and Positioning, Navigation, and Timing Frequency Allocations and Sharing in the Lunar Region, Recommendation SFCG 32-2R4 at recognizing b (Jul. 27, 2022), https://bit.ly/3Z3LdpN.

[79] *See* 47 C.F.R. § 25.112(a)(3).

[80] *See e.g.*, *Orbcomm License Corp.*, Order and Authorization, 23 FCC Rcd 4804 ¶ 20 (IB and OET 2008); *Intelsat North America, LLC*, Order, 22 FCC Rcd 11989 ¶ 10 (IB 2007).

conformance with current international allocations. These may, for example, be operations that can be conducted immediately on an unprotected and non-harmful interference basis and do not represent a "placeholder" for future service after a new international allocation is adopted.] Therefore, we propose to amend the acceptability criteria to place these waiver requests on an equal procedural footing with other requests for waiver of substantive rules, and allow them to be accepted for filing. [81]

Given this tentative decision, this rule should not apply for the present application that seeks authority for frequency bands not yet allocated internationally for space research service or inter-satellite service allocations. All proposed operations can operate immediately on a non-interference, non-protected basis in light of the spectrum sharing possibilities and coordination commitments outlined in this document.

C. 47 C.F.R. § 25.217 (Default Service Rules)

Certain technical rules apply to FCC authorization holders operating a satellite system in a frequency band granted after a domestic frequency allocation has been adopted for that frequency band but before any frequency-band-specific service rules have been adopted for that frequency band.[82] Default service obligations include service-area coverage and frequency re-use mandates.[83] When adopting the default service rules, the Commission explained that "one of its primary goals . . . is to expedite the satellite licensing process, and default service rules further that goal."[84] Additionally, the default service rules "further the public interest by enabling licensees to proceed with their business plans more quickly than would be possible otherwise."[85]

The Commission has adopted domestic space research allocations in S- and X-band frequencies without imposing specific service rules. Lockheed Martin seeks relief from the default service rules because they are not applicable to Moon-centric operations. The service-area coverage mandate applies only to Earth-centric operations. Compliance with any analogous coverage mandate would result in Lockheed Martin providing service to Earth locations with no lunar activity and pose interference and cost concerns given the greater power necessary for lunar-to-Earth communications. Further, compliance

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[81] *See Expediting Initial Processing of Satellite and Earth Station Applications*, Notice of Proposed Rulemaking, IB Docket No. 22-411, FCC 22-95, ¶ 13 (rel. Dec. 22, 2022).

[82] *See* 47 C.F.R. § 25.217.

[83] *See id.* § 25.217(b)(1) (referencing § 25.143(b)(2)(ii) and 25.210(f)).

[84] *Amendment of the Commission's Space Station Licensing Rules and Policies*, Report and Order et al., 18 FCC Rcd 10760 ¶ 54 (2003).

[85] *Id.* ¶ 55

with the frequency re-use mandate is also unnecessary. Another lunar or cislunar operator filing prior or subsequent to Lockheed Martin in the same frequency bands can co-exist because all parties will not materially constrain existing and future operations in the requested frequency bands given the spectrum sharing and coordination commitments outlined in this document. Strict adherence to the default service rules would impede licensing and business plans and, therefore, run counter to the rule's objectives.

D. 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.[86] It, however, 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.[87] In these cases, the Commission processes NGSO satellite system applications under the first-come, first-served procedure adopted for GSO satellite systems.[88] When waiving processing rounds,

> the Commission has relied on the applicants' demonstrations that they can avoid interference events through means such as scheduling of transmissions[] and would not preclude future entrants from using the same spectrum. For example, where a satellite operates with a limited number of earth stations for purposes of downlinking sensor data during relatively short periods of time, it may be possible for such a satellite system to accommodate future entrants utilizing the same frequency bands. The spectrum demands of such systems differ substantially from the requirements for full-time system availability that characterize the NGSO-like systems provided for by the processing round rule.[89]

The lunar surface space stations' Earth and Moon communications would neither constrain current operators nor preclude future entrants in any bands proposed here and should receive consideration outside a processing round. Lockheed Martin's system does not require full-time system availability. The result is co-frequency sharing is possible through the NASA LSMP, ITU, and other coordination mechanisms where parties can schedule communications based on geography, time, and/or frequency separation. The overall spectral environment and limited possible interference

[86] *See* 47 C.F.R. §§ 25.156, 25.157.

[87] *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).

[88] *See* 47 C.F.R. § 25.158.

[89] *Streamlining Licensing Procedures for Small Satellites*, Notice of Proposed Rulemaking, 33 FCC Rcd 4152 ¶ 42 (2018).

geometries also permit sharing. Not many parties will occupy the lunar surface given the significant time and costs necessary to design, launch, and land 380,000 km away on the Moon; the large lunar surface area that can support post-landing activities; and the short operational transits and lifetimes due to the limited energy available and harsh lunar conditions (as further described in Attachment A (Space Debris Mitigation Plan)). Moreover, the uniqueness of this application can operate as a "pathfinder" for future lunar operations and, as such, should be granted expeditiously without need for a processing round.

i. Earth 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[90] and, therefore, no mutual exclusivity existed.

The lunar surface space stations would operate no differently. Spectrum sharing would be possible because the lunar surface space stations 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, lunar surface space stations and Earth stations belonging to other systems would have to travel through the antenna beam of Lockheed Martin's lunar surface space stations and Earth stations and transmit or receive at the exact same time in the same beamwidth. In such an unlikely event, the resulting interference could be avoided by coordinating the communications and using frequency separated channels so that the communications do not occur simultaneously. As noted above, Lockheed Martin will coordinate its spectrum use with the appointed lunar spectrum manager using the NASA LSMP.

ii. Moon Communications

The lunar surface space stations would communicate with space assets on the Moon or in the Moon's orbit.

For lunar surface only links, processing rounds are unnecessary. *First*, in Wi-Fi bands, Lockheed Martin would satisfy all applicable 802.11ac and other international standards when deploying lunar surface space stations to allow an interference-free environment. *Second*, in 5G bands, Lockheed Martin would employ 3GPP standards and coordinate with all co-frequency operators on the lunar surface. Such a coordination arrangement is common. Lockheed Martin will use the NASA LSMP and has experience coordinating

[90] *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).

with the NASA JPL and Goddard, ESA, LASP, UAE Space Agency, and ISRO in other mission contexts.

For similar space-to-space links, processing rounds have been waived. For example, before its license was rendered null and void, Audacy was required to coordinate with other inter-satellite services, but its application was granted without need for a processing round.[91] The Commission similarly declined to initiate a processing round and applied the same terms and conditions that it placed on Audacy's authorization for Boeing's inter-satellite service.[92] As such, Boeing was required to coordinate with existing co-frequency operators.[93] The same situation applies here. Given the Moon's distant location from the radiofrequency-congested environment on and surrounding the Earth and the limited number of space assets that might operate simultaneously near or on the Moon, spectrum sharing is possible. Furthermore, Lockheed Martin plans to follow the accepted recommendations on bandwidth efficient modulations (despite the Moon's distant location from the radiofrequency-congested Earth environment), 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.[94] Given the limited operational experience with lunar communications, it is appropriate to grant this application so that future processing rounds, if needed at all, can be considered.

E. 47 C.F.R. § 25.159 (Pending Application and Unbuilt Satellite System Limits)

A space station authorization applicant or licensee may not seek access to frequencies already pending for or authorized to the same party for a separate NGSO system.[95] Lockheed Martin's Parsec lunar orbiting satellite NGSO application remains pending and includes the S-, X-, and Ka-band frequencies requested in the present NGSO application.

Good cause exists for waiver of this rule. The unbuilt NGSO system rule may be a hinderance to the acceptability of legitimate satellite applications. Although filed separately, the previously requested two Parsec lunar orbit satellites (which will likely launch by next year (2024)) and currently requested lunar surface space stations represent one system relying on a comprehensive, interoperable frequency plan. The

[91] *See Audacy Corporation*, Order and Authorization, 33 FCC Rcd 5554 ¶ 27 (2018); *see also* 47 C.F.R. § 25.279.

[92] *See The Boeing Company*, Order and Authorization, 36 FCC Rcd 16067 ¶¶ 21-22 (2021).

[93] *See id*.

[94] *See e.g.*, 47 C.F.R. § 25.279.

[95] *See id.* § 25.159.

frequencies sought are shareable and are not significantly used on the lunar surface (which is quite difficult to reach given the distance and limited lunar-specific transfer vehicles). Any current operators and later entrants are not prevented from using this spectrum on the Moon if Lockheed Martin failed to deploy.

F. 47 C.F.R. §§ 25.164 (Deployment Milestones), 25.165 (Surety Bond Obligations)

An NGSO licensee must deploy 50% of its authorized NGSOs within six years of its authorization and 100% of its authorized NGSOs within nine years of its authorization.[96] Surety bond obligations apply each day the authorized system fails to satisfy the buildout milestones.[97] Both rules aim to prevent spectrum warehousing.

Complete relief from both rules is appropriate. Any penalty must be commensurate with the potential harm. Lunar space is unchartered. The technology development and financing; significant distance between Earth and Moon (and resulting travel time); and limited lunar-specific launch capabilities, energy options while on the lunar surface, and operational lifetimes, among other things, can disrupt deployment and operational timelines that are expected with Earth operations. Many of the services contemplated in this application will be devoted to governmental programs over which the applicant has no control as to timing. Earth-centric milestones and surety bonds, therefore, do not make sense in the lunar context. The use or non-use of the requested frequencies does not prevent any other user from accessing this spectrum as discussed throughout this waivers section.

Further, percentage buildout requirements conceptually should not apply to lunar terminals. The lunar surface assets are space stations by definition. But, in practice, they resemble mobile earth station terminals ("METs"), very-small-aperture terminals ("VSATs"), or earth stations in motion. No percentage buildout rules apply to such blanket licensed stations because their implementation is constantly subject to change with no preconceived "build-out" schedule.[98] The same applies here, especially outside the

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[96] *See* 47 C.F.R. § 25.164.

[97] *See id.* § 25.165.

[98] *See, e.g.*, *2000 Biennial Regulatory Review - Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations*, Report and Order, 20 FCC Rcd 5666 ¶ 118 (2005) ("MET licensees should be allowed to bring terminals into use in response to marketplace forces rather than a Commission-imposed milestone schedule."); *Streamlining the Commission's Rules and Regulations for Satellite Application and Licensing Procedures*, Report and Order, 11 FCC Rcd 21581 (1996) (eliminating the four-year implementation period for VSATs allowing VSAT licensees to

context of established earth station rules and operation. Given the limited operational experience with lunar communications, it is appropriate to grant this application so that future milestone and surety bond rules, if needed at all, can be considered.

G. 47 C.F.R. § 25.114(c) (Schedule S)

A Schedule S, including additional technical information, accompanies this application. Lockheed Martin cannot accurately describe its system in certain respects given Schedule S limitations. Below are certain aspects of the proposed lunar surface space station system that fall into this category:

- orbit type,
- total number of satellites in the active constellation,
- orbital planes,
- orbital parameters, and
- antenna gain contour plots.

To the extent necessary, Lockheed Martin requests waiver of these Schedule S aspects in light of these parameters' irrelevancy with respect to lunar surface operations.

VII. ADDITIONAL INFORMATION

The existing domestic and international frameworks can accommodate the novel concept of operations the present application introduces.

A. Domestic

FCC space stations. Communications assets on the lunar surface or in the lunar orbit are space stations. For inter-satellite service, the Commission does not distinguish between the two, as explained in section I.D. Both are space stations. For space research service, the Commission adopts the ITU definition: it is a "radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes."[99] with a spacecraft defined as a "man-made vehicle which is intended to go beyond the major portion of the Earth's atmosphere."[100] "Other

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construct their network over the course of their ten year license term). *See generally* 47 C.F.R. § 25.133.

[99] 47 C.F.R. § 2.1.

[100] 47 C.F.R. § 25.103. *See also* ITU RR Nos. 1.55, 1.178; Final Acts of the Extraordinary Administrative Radio Conference to Allocate Frequency Bands for Space Radiocommunication Purposes, Annex 1 at 27 (1963), https://bit.ly/3RWOiFF (RR No. 84AM).

space objects," however, is not yet defined in the ITU Radio Regulations or FCC rules. But the ITU and U.S. administration have proposed previously the following all-encompassing definition adoption for objects in space: "[n]atural or artificial objects, such as the planets, satellites and space vehicles, maintaining sustained motion beyond the major portion of the earth's atmosphere. Objects in space do not include such objects as aircraft, balloons, missiles or rockets intended for flight between points on the earth's surface."[101] Furthermore, ITU BR International Frequency Information Circular (Space Services) Preface, ITU Space Research Communication Handbook, and at least one relevant ITU-R recommendation do not distinguish among space assets on a celestial body's surface or in orbit.[102] As a result, lunar orbit spacecraft, probes, surface rovers, and base stations should be considered to constitute one space research service space station class without further distinction. Additional experience may result in subcategories or new classes of service, but conjectural future results should not impede gaining the experience today that is necessary to make such future decisions.

FCC NGSO blanket space station licensing. The Part 25 licensing framework accepts blanket license applications for non-technically identical space stations regardless of orbital location. Blanket licensing is permissible for "multiple space stations in non-geostationary-orbit" with a space station being a "station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere."[103] As noted above, the proposed space stations would operate on the Moon's surface, well beyond the Earth's orbit. For such blanket license applications with non-technically identical satellites, submitting certain administrative details is necessary.[104] Lockheed Martin presents this information in the instant application's Form 312, Schedule S, and narrative.

National Oceanic and Atmospheric Administration ("NOAA") licensing. Some lunar surface space stations may carry imaging equipment and require NOAA licensing. Lockheed Martin (or, as appropriate, the ultimate space station user) would secure all necessary NOAA licensing before launch.

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[101] Documents of the Administrative Radio Conference (CAR-59), Document No. 326-E at 2 (1959), https://bit.ly/3PCnf0I; 2nd Series of Proposals for the International Radiocommunication Conference, at 45.1 (1959), https://bit.ly/3vdnCXp.

[102] *See* ITU-R Radiocommunication Bureau Preface to the BR International Frequency Information Circular BR IFIC (Space Services), at 167 (Feb. 2023), https://bit.ly/3zuvm9R; ITU-R Handbook on Space Research Communication, at 3-4 (2014), https://bit.ly/3OvTMUH; Factors affecting the choice of frequency bands for space research service deep-space (space-to-Earth) telecommunication links, Report ITU-R SA.2167, at Table 2 (Sept. 2009), https://bit.ly/3BjPcpI.

[103] 47 C.F.R. § 25.103.

[104] *See id.* § 25.114(a)(2).

B. International

International Telecommunication Union. Lockheed Martin would satisfy pertinent ITU requirements for each phase of its application.

- *Advance publication information.* For systems that it issues launch-and-operational authority, the Commission submits advance publication information ("API") to the ITU.[105] In concert with this application, Lockheed Martin submits the ITU API and, in Attachment C (ITU Cost Recovery Declaration), unconditionally accepts all associated cost recovery responsibilities.
- *Lunar and deep space.* ITU space station filings on file already specify the Moon as a reference body,[106] and ITU Radio Regulations establish extraterrestrial protections, such as those for radio astronomy in the shielded zone of the Moon, which Lockheed Martin commits to satisfying.[107] Furthermore, ITU Radio Regulations regulate deep space activity without establishing any new ITU region or regulatory framework.[108]

Non-ITU International obligations. Lockheed Martin commits to –

- satisfying U.S. international obligations under the Outer Space Treaty and Artemis Accords[109] based on FCC supervision and rule-based authorization of the proposed operations.
- coordinating with federal and commercial counterparts, including the U.S. State Department; Federal Aviation Administration; Department of Commerce Office of Space Commerce; and NTIA, to deploy all lunar surface space stations without

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[105] *See id.* § 25.111.

[106] For data item A.4.b.2, "L" is the reference body code for the Moon. *See* ITU-R Radiocommunication Bureau Preface to the BR International Frequency Information Circular BR IFIC (Space Services), at Table 8 (Feb. 2023), https://bit.ly/3zuvm9R.

[107] *See, e.g.*, ITU RR Article 22, Section V.

[108] A deep space mission operates "at distances from the Earth equal to, or greater than, 2×10^6 km." *Id.* No. 1.177.

[109] The Artemis Accords are a set of shared principles, grounded in the Outer Space Treaty, which seek to govern the safe and transparent use of space for exploration, scientific, and commercial purposes. As of January 2023, the following 23 nations have signed the Artemis Accords: United States, Australia, Bahrain, Brazil, Canada, Colombia, France, Israel, Italy, Japan, Luxembourg, Mexico, New Zealand, Nigeria, Poland, Republic of Korea, Romania, Rwanda, Saudi Arabia, Singapore, Ukraine, United Arab Emirates, and United Kingdom. *See The Artemis Accords: Principles for a Safe, Peaceful, and Prosperous Future*, NASA, https://go.nasa.gov/3Ivh11R (last viewed Feb. 21, 2023).

jeopardizing public health and safety, safety of property, U.S. national security or foreign policy interests, or international obligations of the United States.

C. Miscellaneous

Lockheed Martin's ownership structure appears in Attachment D (Ownership Information) and technical certification appears in Attachment E (Technical Certification).

VIII. CONCLUSION

Lockheed Martin aims to deploy the world's first commercial lunar surface communications system on a scale that serves the public interest. Authorizing the requested lunar surface space stations before their initial first-quarter 2024 launch would promote U.S. lunar and cis-lunar research and exploration.

Respectfully submitted

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March 15, 2023

ATTACHMENT A
(SPACE DEBRIS MITIGATION PLAN)

Keeping space safe and sustainable is paramount to Lockheed Martin. Consistent with this mission, the lunar surface space stations[1] will satisfy the FCC space debris mitigation rules in 47 C.F.R. § 25.114(d)(14), as amended recently, as well as NASA standards[2] to ensure safe design build, minimize collision risk, and achieve post-mission disposal success.[3]

Rule or Standard	Text Summary	Compliance[4]
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 items.
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 will limit the amount of debris released in a planned manner during normal operations. Manufacturing and resource utilization missions will be designed to minimize or eliminate free debris during normal operations. Landing missions will not require additional deployments beyond the separation from the launch vehicle.
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	Lockheed Martin has assessed and will limit the probability that the lunar surface space stations will become a source of debris by collision with small debris or meteoroids that would cause loss of control

[1] This appendix evaluates Phase 1 and Phase 2 lunar space stations only. Phase 3 lunar space stations would be assessed in a subsequent application.

[2] *See generally* Process for Limiting Orbital Debris, NASA-STD-8719.14C (2021), https://go.nasa.gov/3KubhXh.

[3] *See generally Mitigation of Orbital Debris in the New Space Age*, Report and Order et al., 35 FCC Rcd 4156, Appendix A (2020). Section 25.114(d)(14) has been amended, but certain provisions have not received Office of Management and Budget approval. Lockheed Martin will satisfy current and amended rules as appropriate.

[4] For all relevant calculations in this appendix, Lockheed Martin used National Aeronautics and Space Administration Debris Assessment Software v.3.2.2.

Rule or Standard	Text Summary	Compliance[4]
	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	and prevent disposal. The rule is inapplicable because no lunar surface space stations will have specific instruments or equipment supporting their disposal.
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 will limit 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 the shutdown at the end of mission life, these space stations will vent all pressurized systems in a controlled fashion. They will deplete all residual fuel and discharge all batteries. 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 will limit the probability of the lunar surface space stations 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 items.
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	The probability of collision between any lunar surface space station and other large objects (10 cm or larger in diameter) during the total orbital lifetime of a single lunar surface space station is less than 0.001.

Rule or Standard	Text Summary	Compliance[4]
	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	Mobile missions will control their motion to avoid stationary debris. The probability of large object collisions 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 Moon's surface area is 14.6 million square miles (38 million square km), slightly less than the total surface area of the continent of Asia (17.2 million square miles or 44.5 million square km).[5] Lockheed Martin's lunar surface space stations will have generally unfettered access in this large area, where only few other operators' space stations currently operate or plan to operate. To mitigate collision risk between Lockheed Martin space stations and these other space stations, Lockheed Martin will coordinate physical operations with the owner/operators of the other lunar surface space stations using NASA LSMP resources.[6] Lockheed Martin has experience of such coordination with NASA JPL and Goddard, ESA, LASP, UAE Space Agency, and ISRO in other mission contexts. Updated location information will be shared across the respective teams to

[5] *See* Tim Sharp et al., *How big is the moon?*, Space.com (Feb. 7, 2022), https://bit.ly/3cK7dnu.

[6] Coordination with NASA LSMP and review of public resources, such as the ITU Space Networks System database and Lunar Resource Registry, would inform Lockheed Martin about the current and planned missions and associated owners and locations. *See, e.g.*, Lunar Resources Registry, https://bit.ly/3CZmbAt (last viewed Feb. 21, 2023).

Rule or Standard	Text Summary	Compliance[4]
		permit the performance of "Close Approach" analysis and additional coordination if an expected close approach is below a certain threshold. Furthermore, Lockheed Martin is exploring the possibility of deploying a database to map operational and disposal areas and passive and/or active identification beacons to assist collision avoidance on the Moon.
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 lunar surface space stations deploy (if necessary) only after crossing orbital altitudes of any inhabitable space stations in low-Earth orbit. Should any inhabitable space stations operate in lunar orbit, Lockheed Martin expects to coordinate operations during the descent through the lunar orbit.
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	Throughout the mission, lunar surface space stations will not maintain any orbital tolerance given that operations will occur on the Moon itself. But, in general, the *fixed* space stations will not maneuver and the *mobile* space stations will generally move only few kilometers[7] and know their position within 10 meters when doing so.[8]

[7] To date, the longest distance covered by a lunar surface space station is approximately 38.62 km (24 miles). *See, e.g.*, *Every rover, ranked by distance traveled on the moon and Mars*, Mashable (Aug. 14, 2021), https://bit.ly/3qj8l4h.

[8] To determine their positioning, the mobile lunar space stations have navigation services (*i.e.*, 2 W dedicated ranging and Doppler) and may utilize additional technologies such as Earth-based ranging and Doppler and local terrain features from lander imagery.

Rule or Standard	Text Summary	Compliance[4]
	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	Collision avoidance for mobile assets should not pose concern because, as described above, the Moon is a large generally unoccupied celestial body and most lunar surface space stations do not transit large distances. In contrast to the *mobile* lunar surface space stations, the *fixed* lunar surface space stations will not have maneuvering capability. Collision avoidance should not pose concern for these assets either because, as described above, operator-to-operator coordination, database registration, and active and/or passive identification tools will aid collision avoidance.
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 space stations involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying lunar surface space station operations.
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	N/A. The lunar surface space stations will not operate in the geostationary orbit.

Rule or Standard	Text Summary	Compliance[4]
	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	
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 lunar surface space station will be trackable given its smallest dimension size. No station will have dimensions less than 10 cm.
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 lunar surface space stations using communications to/from the Parsec satellites and new Earth-based telescope technologies.[9] Immediately following deployment, the Parsec satellites and other tracking assets will begin receiving trajectory data from the launch provider and will adjust their pointing based on the current ephemeris to identify the lunar surface space stations 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 lunar surface space stations with the 18th Space Control Squadron or successor entity.

[9] *See, e.g.*, Vishnu Reddy, *Building a catalog of lunar trash to track*, Moon Daily (Feb. 7, 2023) (describing the efforts of the University of Arizona to track debris in lunar orbit); Alexandra Witze, *Space junk heading for Moon will add to 60+ years of lunar debris*, Nature (Feb. 28, 2022), https://go.nature.com/3BfweQz.

Rule or Standard	Text Summary	Compliance[4]
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	Proximity operations can only occur with mobile space stations on the lunar surface, and debris-mitigation and collision-avoidance plans will follow those described above. These include operator-to-operator coordination, database registration, and active and/or passive identification tools.
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	All lunar surface space stations will remain on the Moon after mission completion and controlled passivation because terrain, fuel, sunlight, and low-reliability of low-Moon orbit limits prevent any other disposal option at this time. For these reasons, many U.S. government agencies have followed this approach for their lunar surface assets.[10] The Moon's large surface area, coupled with Lockheed Martin's limited ask and commitment to coordination and registration of its lunar surface assets at

[10] *See, e.g.*, Karl Tate, *The Moon: Space Programs' Dumping Ground (Infographic)*, Space.com (Dec. 14, 2012), https://bit.ly/3KWo1nJ.

Rule or Standard	Text Summary	Compliance[4]
		their end of life (at a minimum), would allow other parties continued access to the large lunar surface. Consistent with NASA orbital debris mitigation standards, disposal of these space stations will be coordinated with NASA's Planetary Protection Officer to meet the applicable planetary protection requirements.[11] Further, Lockheed Martin commits to exploring other alternate disposal solutions, including graveyard disposal sites, for future missions as its technology and experience advance.
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. The lunar surface space stations will not operate in the geostationary orbit.
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. The lunar surface space stations will not terminate operations in low-Earth orbit.
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	N/A. The lunar surface space stations will not use a storage orbit or long-term atmospheric re-entry maneuver. The rationale for the selected disposal plan appears above.
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	See following items.

[11] *See generally* Process for Limiting Orbital Debris, NASA-STD-8719.14C § 4.6.1.6 (2021), https://go.nasa.gov/3KubhXh.

Rule or Standard	Text Summary	Compliance[4]
	apply	
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 lunar surface space station will be discarded where it operates and passivates, resulting in a 1.0 disposal success rate.
25.114(d)(14)(vii)(D)(2)	If planned disposal is by atmospheric re-entry, the statement must also include	N/A. The lunar surface space stations 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. The lunar surface space stations 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. The lunar surface space stations will not terminate operations by atmospheric Earth re-entry.
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	Lockheed Martin includes its post-mission disposal plans in this FCC application.

Rule or Standard	Text Summary	Compliance[4]
	Oceanic and Atmospheric Administration for review	
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 is expected to authorize the lunar surface space stations.
NASA-STD-8719.27 (Implementing Planetary Protection Requirements for Space Flight) NASA NPR 8715.24 (Planetary Protection Provisions for Robotic Extraterrestrial Missions)	Coordinate with NASA regarding lunar environment contamination mitigation.	Missions targeting the Moon are categorized as Category II, IIa, or IIb. For the purposes of planetary protection categorization a Permanently Shadowed Region ("PSR") and the lunar poles are defined as locations south of 79°S latitude and north of 86°N latitude. The assignment of specific missions to a planetary protection category is based on the following: • Category II for orbital and flyby missions to Earth's Moon. • Category IIa for missions landing on Earth's Moon but not a PSR and the lunar poles. • Category IIb for missions landing or conducting surface operations on Earth's Moon within a PSR and the lunar poles. Lockheed Martin's lunar surface space stations are classified as categories IIa and IIb. But only a remote chance exists that contamination by the Phase 1 and Phase 2

Rule or Standard	Text Summary	Compliance[4]
		space stations could compromise future investigations due to the lack of biological payloads onboard. Lockheed Martin has collaborated and will continue coordinating with NASA to satisfy all applicable planetary protection requirements, including providing mission-specific documentation and reporting consistent with NASA-imposed mission requirements.
NASA-STD-1008 (Classifications and Requirements for Testing Systems and Hardware to be Exposed to Dust in Planetary Environments)	Minimize dust creation and movement for lunar surface assets landing and transiting the Moon.	NASA proposes a dust mitigation strategy in three components: operational and architecture considerations, passive technologies, and active technologies.[12] Lockheed Martin commits to employing this strategy when designing, landing, and operating lunar surface assets.

[12] *See* M. R. Johansen, *An Update on NASA's Lunar Dust Mitigation Strategy*, NASA (Aug. 31, 2022), https://go.nasa.gov/3CK0xjt.

ATTACHMENT B
(HUMAN RADIOFREQUENCY EXPOSURE MITIGATION PLAN)

FCC applicants must typically satisfy requirements on human exposure to radiofrequency.[1] But the FCC rules largely focus on environmental effects at the Earth's surface with the result that space stations generally have been excluded from environmental review.[2]

In the absence of FCC rules on environmental effects in space, satisfying relevant government directives or industry standards is justified. NASA-STD-3001 Volume 2 explains space crew exposure should remain below the maximum permissible exposure limits for radiofrequency electromagnetic fields, as outlined in Table 7.[3]

Table 7: Maximum Permissible Exposure (MPE) to RF Electromagnetic Fields (modified from IEEE C95.1-2005, lower tier)

Frequency Range (MHz)	RMS Electric Field Strength (E)[a] (V/m)	RMS Magnetic Field Strength (H)[a] (A/m)	RMS Power Density (S) E–Field, H–Field (W/m^2)	Averaging Time[b] $\|E\|^2$, $\|H\|^2$, or S (min)	
0.1 – 1.34	614	$16.3/f_M$	$(1{,}000,\ 100{,}000/f_M^2)$ [c]	6	6
1.34 – 3	$823.8/f_M$	$16.3/f_M$	$(1{,}800/f_M^2,\ 100{,}000/f_M^2)$	$f_M^2/0.3$	6
3 – 30	$823.8/f_M$	$16.3/f_M$	$(1{,}800/f_M^2,\ 100{,}000/f_M^2)$	30	6
30 – 100	27.5	$158.3/f_M^{1.668}$	$(2,\ 9{,}400{,}000/f_M^{3.336})$	30	$0.0636 f_M^{1.337}$
100 – 300	27.5	0.0729	2	30	30
300 - 5000	–	–	$f/150$	30	
5000 - 15000	–	–	$f/150$	$150/f_G$	
15000 – 30,000	–	–	100	$150/f_G$	
30,000 – 100,000	–	–	100	$25.24/f_G^{0.476}$	
100,000 – 300,000	–	–	100	$5048/[(9f_G-700)f_G^{0.476}]$	

Note: f_M is the frequency in MHz; f_G is the frequency in GHz.
(a) For exposures that are uniform over the dimensions of the body such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the MPEs in the table. For non-uniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area) or a smaller area, depending on the frequency, are compared with the MPEs in the table. For further details, see IEEE C95.1-2005, notes to Table 8 and Table 9.
(b) The left column is the averaging time for $|E|^2$; the right column is the averaging time for $|H|^2$. For frequencies greater than 400 MHz, the averaging time is for power density (S).
(c) These plane-wave equivalent power density values are commonly used as a convenient comparison with MPEs at higher frequencies and are displayed on some instruments in use.

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[1] *See* 47 C.F.R. § 1.1307(a)-(b).

[2] *See Space Exploration Holdings, LLC*, Order and Authorization et al., 36 FCC Rcd 7995 ¶ 72 (2021).

[3] *See* NASA Space Flight Human-system Standard Volume 2: Human Factors, Habitability, and Environmental Health, NASA-STD-3001, Vol. 2, Rev. C § 6.8.2.1 (last approved Apr. 8, 2022).

The NASA standard also emphasizes the importance of minimizing exposure from all sources of radiation using the "as low as reasonably achievable" ("ALARA") principle.[4] Non-ionizing radiation, such as radiofrequency emissions, can be "managed through mission architecture, system design, procedures and planning, and application of appropriate countermeasures."[5] Protection from such exposure is ALARA "when the expenditure of further resources would be unwarranted by the reduction in exposure that would be achieved."[6]

Lockheed Martin commits to satisfying the relevant limits and taking all precautions to achieve ALARA. Except as noted below, all transmitters will use less than 40 dBm EIRP and, therefore, may operate within 10 cm of exposed skin without issue. For transmitters using 2025-2110 MHz, 2200-2290 MHz, 7190-7235 MHz, 8450-8500 MHz, 22.55-23.55 GHz, and 25.5-27.5 GHz during communications to or from Earth or lunar-orbit satellites, the transmitter EIRP may exceed 40 dBM EIRP and pose danger to exposed skin within 1 to 10 meters. Mitigating such radiofrequency exposure on the Moon's surface is possible by taking at least three measures. Lockheed Martin will (1) collaborate with NASA and other partners to review crew before launch and monitor crew radiation exposure levels after launch; (2) equip human crew with tested and space hardened protective suits, including shielding around spacesuit and handset radios, that prevent radiofrequency exposure; and (3) ensure all highly directive antennas are pointed toward the lunar orbiting Parsec satellites with fencing and shielding present as appropriate to protect all human crew.

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[4] *Id.* § 6.8.1.

[5] *Id.* § 6.8.2.

[6] *Id.* § 6.8.1.2.

ATTACHMENT C
(ITU COST RECOVERY DECLARATION)

March 15, 2023

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

Subject: ITU Cost Recovery Declaration for the PARSEC-SURFACE Non-Geostationary Orbit 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 above referenced system. Please address all cost-recovery inquires, and ITU correspondence and filings, related to the 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 system.

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
+1 703-413-5747

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	14.36%

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
Tim Cahill	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
2121 Crystal Drive
Suite 100
Arlington, VA 22202

ATTACHMENT E
(TECHNICAL CERTIFICATION)

I, Scott Kotler, hereby certify, under penalty of perjury, that I am the technically qualified person responsible for the preparation of the engineering information contained in the technical portions of the foregoing application and the related attachments, that I am familiar with Part 25 of the Commission's rules, and that the technical information is complete and accurate to the best of my knowledge and belief.

/s/ Scott Kotler

Scott A. Kotler
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March 15, 2023