Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of *Intuitive Machines, LLC* Application for Authority to Launch and Operate the NOVA-C Lunar Lander	Call Sign: _____ File No. _____

Application of Intuitive Machines, LLC

Intuitive Machines, LLC ("Intuitive Machines"), hereby requests authority under Section 25.123 of the Federal Communications Commission's ("Commission") streamlined small spacecraft rules[1] to launch and operate the NOVA-C Lunar Lander ("NOVA-C") for a period of up to 60 days (21 nominal),[2] using spectrum in the 2025-2110 MHz, 2200-2290 MHz, and 5 GHz bands (the "IM-1 Mission").

The IM-1 Mission is part of the Commercial Lunar Payload Services ("CLPS") program sponsored by National Aeronautics and Space Administration ("NASA") to explore the surface of the Moon. The NOVA-C will deliver important payloads to the lunar surface, including operations that will advance U.S. commercial, government, and scientific interests.

[1] *See* 47 C.F.R. § 25.123 ("This section shall … apply to applicants for space stations that will operate beyond Earth's orbit and that are able to certify compliance with the certifications … of this section").

[2] Due to limitations in the Schedule S software, the smallest time entry for estimated spacecraft lifetime is 1 year. This narrative clarifies that the requested license is for 60 days.

Accordingly, the IM-1 Mission is critical to furthering the national space policy objectives of the United States and grant of this license would strongly serve the public interest.

I. BACKGROUND

Under Space Policy Directive 1 ("SPD-1"), the President announced that it is the goal of the U.S. government to return human beings to the Moon for the first time in a half-century. SPD-1 established the mission of the National Aeronautics and Space Administration to:

> "Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities. Beginning with missions beyond low-Earth orbit, *the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations*[.]"[3]

A critical component of this mission to return human beings to the Moon, dubbed the Artemis Program,[4] begins with the CLPS effort to enlist commercial partners to quickly land scientific instruments and technology demonstrations on the Moon. These science and technology payloads lay the foundation for human missions to the lunar surface to begin in 2024.

Intuitive Machines, founded in 2013, is leading an effort to develop a commercial Lunar Payload and Data Service ("LPDS") which provides transit to lunar orbit, intact payload delivery to the lunar surface, data communications, and power services to assets both in lunar orbit and on the surface. Intuitive Machines has been selected by NASA as part of its CLPS program to send robotic landers, rovers, and other payloads to the Moon, beginning in 2022.

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[3] Space Policy Directive 1: Reinvigorating America's Human Space Exploration Program (Dec. 11, 2017) ("SPD-1") (emphasis added), *available at* https://www.whitehouse.gov/presidential-actions/presidential-memorandum-reinvigorating-americas-human-space-exploration-program/.

[4] Artemis is the twin sister of Apollo, and the Goddess of the Moon. *See* NASA, *The Artemis Plan: NASA's Lunar Exploration Program Overview* (Sept. 2020) ("*Artemis Plan*"), *available at* https://www.nasa.gov/sites/default/files/atoms/files/artemis_plan-20200921.pdf.

The IM-1 Mission will cover end-to-end commercial payload delivery, including payload integration, mission operations, launch from Earth and culminating with landing on the surface of the Moon. Launch of the NOVA-C is currently scheduled for early 2022. The NOVA-C, the first wholly private lunar lander, will deliver commercial cargo in addition to five NASA payloads to the lunar surface, conducting scientific research and technology demonstrations. The NOVA-C will land in Mare Serenatis at its first landing opportunity. The NOVA-C will examine the site with imaging instruments, look at interactions of engine plumes and the surface geology, radiation and plasma environment investigations, a telescope, and technology demonstrations. As the launch window/semester progresses, the landing site moves eastward by many degrees of longitude.

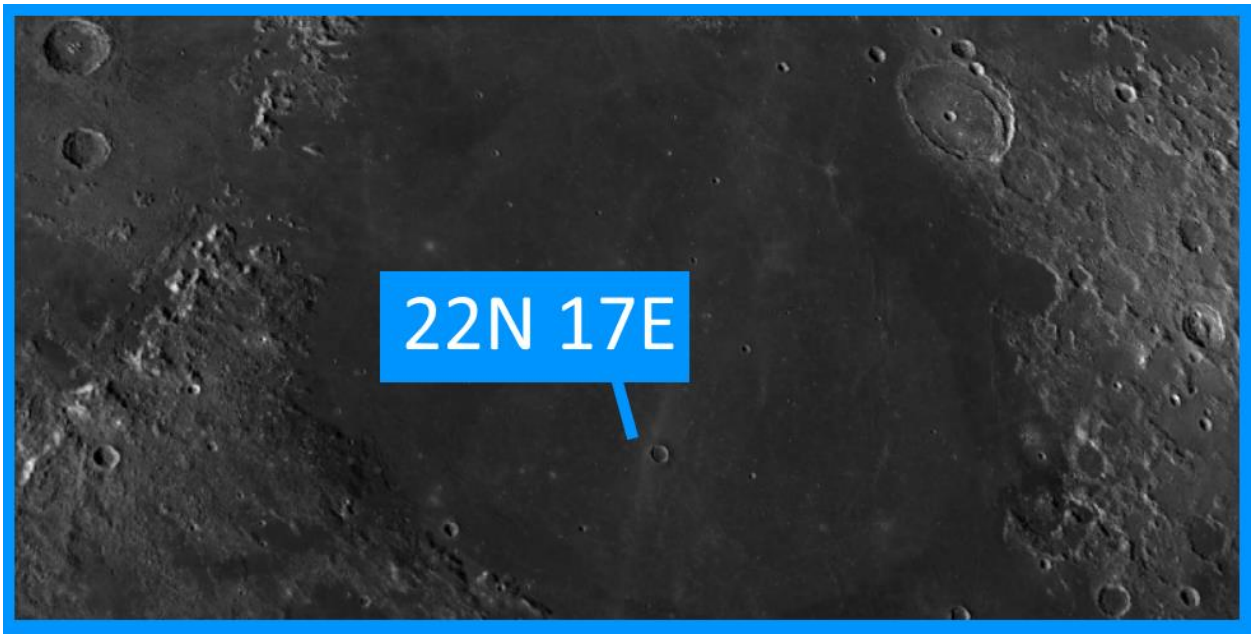

Figure 1: Lunar Landing Site

The NOVA-C will test its Precision Landing and Hazard Avoidance ("PLHA") landing system, paving the way for improved landing navigation for crewed and un-crewed missions later in this decade. The NOVA-C will capture feature-rich raw optical images of the lunar

surface to perform Terrain Relative Navigation ("TRN") computations and land within 200 meters of the intended landing site. Methods and systems used by Intuitive Machines will enhance lunar/planetary vision-based navigation for landing, surface mobility, rendezvous, and docking, rendering it cheaper and easier to use in the future.

Accordingly, Intuitive Machines respectfully requests that the Commission grant this application expeditiously to allow Intuitive Machines to prepare launch, transit, and landing operations of the NOVA-C.

II. IM-1 MISSION DESCRIPTION

A. Mission Phase Overview

The IM-1 Mission will consist of four phases: launch, transit, lunar orbit, and lunar surface. Nominal mission duration is approximately 21 days, including a 3 to 8-day transit from Earth, 1 day in low-lunar orbit, and a 14-day operational period on the lunar surface (during lunar daylight). By day 37, Intuitive Machines will attempt to make additional spacecraft contacts to see if the NOVA-C survived the harsh lunar night. Each phase of the mission is briefly described below.

1. Launch Phase

The NOVA-C will launch aboard a SpaceX Falcon 9, Block 5 rocket in early 2022. In launch phase, NOVA control in Houston will begin tracking the NOVA-C upon launch vehicle separation. The launch phase ends after an approximate 19-hour Lunar Transfer Orbit ("LTO") and Trans-Lunar Injection ("TLI") burn.

2. Transit Phase

During transit, primary communication will be via two transceivers (≤ 8W) built by Thales Alenia ("Thales"), in conjunction with four low-gain (3 dBiC) hemispherical antennas. Two-tone ranging and doppler data will be obtained. Both transceivers will be active for

receiving, using independent antennas, while only the primary transceiver will be active on transmission. The NOVA-C will also be equipped with two Quasonix transmitters (≤ 25W), primarily for data download from the lunar surface. However, the NOVA-C may also intermittently use one of these, in conjunction with a parabolic, high-gain antenna (transmit only) during transit.

3. Lunar Orbit Phase

Both the Thales and Quasonix transceivers will be used during lunar orbit phase, covering 18 orbits prior to descent and landing on the lunar surface. During each orbit of the Moon, NOVA Control will lose contact with NOVA-C when it goes behind the Moon and the Lunar Tracking Telemetry and Command network ("LTN") will need to re-acquire the NOVA-C when in line-of-sight.

4. Lunar Surface Phase

This phase of the mission is designed to take advantage of lunar daylight, lasting approximately 14 days. During the lunar surface phase, the Quasonix transmitters will relay science data, while the Thales transceivers will continue to conduct TT&C operations. These radio operations are described more fully below and in the accompanying Technical Appendix and Schedule S. At the end of 14 days, the NOVA-C enters lunar night. By day 37, Intuitive Machines will attempt to make additional spacecraft contacts to see if it survived the harsh conditions to the subsequent sunrise. Intuitive Machines will request appropriate authority in the event that subsequent operations are possible and desired beyond the expiration of this authorization (~60 days). Additional use of unlicensed spectrum is noted, as appropriate, in the following lunar payload descriptions.

B. NASA Payloads

1. Laser Retroreflector Array ("LRA")

LRA is a collection of eight approximately half-inch (1.25 centimeter) retro-reflectors—a unique kind of mirror that is used for measuring distance—mounted to the NOVA-C. This mirror reflects laser light from other orbiting and landing spacecraft to precisely determine the NOVA-C's position. It requires no power or communications from the NOVA-C and can be detected by future spacecraft orbiting or landing on the Moon. It is being provided by NASA's Goddard Space Flight Center in Greenbelt, Maryland.

2. Navigation Doppler Lidar for Precise Velocity and Range Sensing ("NDL")

The NDL is a light detection and ranging-based ("LIDAR") sensor composed of a three-beam optical head and a box with electronics and photonics that will provide extremely precise velocity and range sensing during descent and landing of the NOVA-C that will tightly control navigation precision for a soft and controlled touchdown on the Moon. NDL is being developed by Langley Research Center in Hampton, Virginia.

3. Stereo Cameras for Lunar Plume-Surface Studies ("SCALPSS") Technology

SCALPSS will capture video and still image data of the NOVA-C's plume as the plume starts to impact the lunar surface until after engine shut off, which is critical for future lunar and Mars vehicle designs producing less site contamination. It is being developed at NASA Langley, and leverages camera technology used on the Mars 2020 rover. The SCALPSS system is directly connected to the NOVA-C and payload data will be relayed back to Earth via the NOVA-C's Quasonix transmitter primarily using the high-gain antenna.

4. Lunar Node 1 Navigation Demonstrator ("LN-1") Science

LN-1 is a CubeSat-sized experiment being developed at NASA Marshall that will demonstrate autonomous navigation to support future surface and orbital operations. The LN-1 will operate in the S-Band at 2256.3 MHz and has flown on the International Space Station ("ISS").

5. Low-Frequency Radio Observations from the Near-Side Lunar Surface ("ROLSES")

ROLSES will use a low-frequency radio receiver system to determine photoelectron sheath density and scale height. These measurements will aide future exploration missions by demonstrating if there will be an effect on the antenna response or larger lunar radio observatories with antennas on the lunar surface. In addition, the ROLSES measurements will confirm how well a lunar surface-based radio observatory could observe and image solar radio bursts. This receive-only payload is being developed at NASA Goddard.

Intuitive Machines understands that the responsible U.S. government agencies for each of the payloads above have secured appropriate authority for the deployment and operation of the payloads.

C. Commercial Payloads

1. SPACEBIT Rover

Upon landing, the NOVA-C will deploy the SPACEBIT Rover on the lunar surface primarily for technology demonstration operations. Both the SPACEBIT Rover and the EagleCAM payload discussed below will communicate with the NOVA-C via conventional 802.11ac in the 5 GHz band, covering a range on the order of a few tens of meters. EagleCAM includes a four-antenna module attached to the NOVA-C (WPEQ-450AC), and a two -antenna

module on the payload itself (QCA9008-TBD1). The SPACEBIT rover will utilize the same two-antenna module as the EagleCAM. Both payloads will use Qualcomm chipsets.

2. EagleCAM

The EagleCAM camera unit will be released just prior to landing, approximately 30 meters above the lunar surface, taking pictures of the dust plume as the NOVA-C descends. EagleCAM is intended to capture the first-ever third person view of a spacecraft extraterrestrial landing and to uncover new scientific findings through dust plume imagery, dust accumulation analysis, and lunar surface imagery.

3. ILO-X Telescope

The International Lunar Observatory Association ("ILOA Hawaii") ILO-X telescope experiment for imaging the arm of the Milky Way galaxy. The instrument includes a dual-camera miniaturized lunar imaging suite that aims to capture some of the first images of the Milky Way Galaxy Center from the surface of the Moon, as well as performing other exploration technology validations – including functionality and survivability in the lunar environment. The ILO-X uses the same camera type as the EagleCAM payload.

4. Tiger Eye

Tiger Eye is a commercially developed radiation measurement sensor modified for space applications, the effectiveness of which will be tested in the lunar environment. The Tiger Eye has previously flown on the ISS. Like the SCALPSS payload, the Tiger Eye is directly connected to the NOVA-C and payload data will be relayed back to Earth via the NOVA-C's Quasonix transmitter primarily using the high-gain antenna.

5. Galactic Legacy Labs ("GLL")

The GLL is a passive data cache (etched metal storage units) mounted on the NOVA-C containing information about the Earth, similar to the golden records attached to the Voyager 1 and 2 spacecraft.

6. Radio Frequency Mass Gauging ("RFMG")

The RFMG is a propellant sweeping/measuring device using a low-power RF signal to measure changes in fluid level and liquid configuration. This is a legacy NASA payload previously flown on the ISS. The device is located within the propellant tank and operates at ultra-low power levels for tank monitoring only. The approximate power level is 0.1 mW. Electromagnetic interference testing has indicated approximate electric field strengths of the order of 80 dBμV/m over the frequency range 100-250 MHz, and 50 dBμV/m over the frequency range 250-500 MHz.[5] Testing conditions utilized a radiating element within an empty, 1-meter composite box. The actual device, as stated, will be located within liquid methane or liquid oxygen, thus further reducing electric field strength. Given these conditions, it is not believed the RFMG constitutes a typical transmitting radio element.

In addition to the payloads described above, the NOVA-C will be equipped with two side-mounted cameras. Limited imagery from these cameras used during transit and on the lunar surface may be used for press releases. Furthermore, additional commercial payloads of opportunity could earn their way onto the flight before launch, and Intuitive Machines will notify the Commission of any such payload modifications and seek appropriate Commission authority for any such payload.

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[5] *See* NASA Glenn Research Center EMI Test Data Report, *Radio Frequency Mass Gauge (RFMG) Measurement System RF Emissions Test Using 1 Meter composite and aluminum* Boxes, GRC-EMI-RPT-294 (2010).

D. NOVA-C Lunar Lander

1. Spacecraft Description

As described more fully in the accompanying orbital debris assessment report, the NOVA-C bus is 2.19 m x 2.385 m x 3.938 m high with three fixed, body-mounted solar panels, and a main propulsion system of liquid methane ("LCH_4") fuel and a liquid oxygen oxidizer ("LOX"), with cold gas helium for pressurization and reaction control systems ("RCS").[6] The attitude determination and control is achieved with redundant inertial measurement units ("IMU"), star trackers, and the RCS. The NOVA-C will be a single payload aboard the SpaceX Falcon 9 booster, separated via a RUAG zero-debris deployment system.

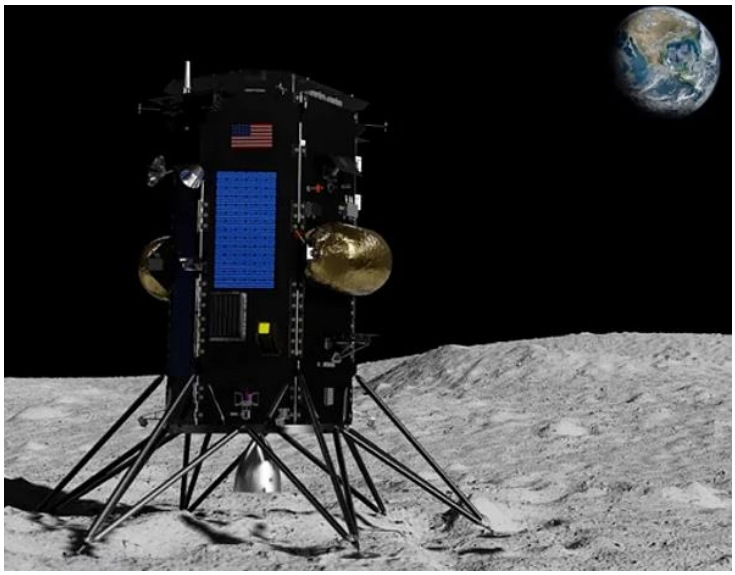

Figure 2: NOVA-C Lunar Lander

The main power system aboard the NOVA-C consists of three batteries, each containing 72 P20 lithium-ion cells, for a total of 216 cells. The batteries are charged by accompanying solar panels, generating a maximum power of 788 W and approximately 28 VDC electrical supply.

[6] *See* Attachment B, Orbital Debris Assessment Report ("ODAR"), § 2.

The NOVA-C has four (4) low-gain antennas for TT&C, and one (1) high-gain antenna for science data downlink. RF switching allows for contingency use of the high-gain antenna for telemetry downlink, as well as the low-gain antennas for data downlink.

The following table lists NOVA-C mass contributions:

Table 1: NOVA-C Mass Contributions

Mass Component	Mass (kg)
Spacecraft Dry Mass	624
Liquid Methane (LCH_4)	845
Liquid Oxygen ("LOX")	422
Cold Gas Helium	17
Total (Wet) Spacecraft Mass	1908

Residual LOX and liquid methane propellant will be vented approximately 30 minutes after landing. Prior to the end of the IM-1 Mission, the helium will also be vented to passivate the RCS and propellant pressurization system. The batteries will be fully discharged approximately nine (9) hours after commencement of lunar night (14 days after landing).

The NOVA-C will be operational for the 14-day lunar daylight mission, after which the solar panels will no longer be able to charge the batteries during lunar night. The estimated spacecraft lifetime is 21 days. It is possible that the batteries may be re-charged via the panels during subsequent lunar days. Intuitive Machines will make an attempt at contact around 37 days after landing to see if the vehicle has survived the lunar night. However, it is highly likely that the NOVA-C will not survive the lunar night. Intuitive Machines will request appropriate authority in the event that subsequent operations are possible and desired beyond the expiration of this authorization (~60 days).

2. Spectrum Usage

The NOVA-C will transmit and receive using S-Band and Wi-Fi frequencies during the planned mission, including: (i) 2025-2110 MHz band (Earth-to-space); (ii) 2200-2290 MHz band

(space-to-Earth); and (iii) 5 GHz band (802.11ac Wi-Fi standard, short-range payload-to-spacecraft communication on the lunar surface only).

a. 2025-2110 MHz Band (Uplink)

The United States Table of Frequency Allocations ("Table of Allocations"), Section 2.106 of the Commission's rules, provides that the 2025-2110 MHz band is allocated to Federal space research and other Federal uses on a co-primary basis with fixed and mobile non-Federal uses.[7] A footnote to that allocation provides that non-Federal, Earth-to-space transmissions may be authorized in the space research and Earth exploration-satellite services in the band "subject to such conditions as may be applied on a case-by-case basis."[8] NOVA-C uplink transmissions shall not cause harmful interference to Federal and non-Federal stations operating in accordance with the Table of Allocations.

Intuitive Machines is coordinating with NASA and other Federal agencies to ensure that spacecraft uplinks will not interfere with U.S. government operations and will operate such uplinks consistent with the outcome of this coordination. As described below, Intuitive Machines requests the Commission waive the Table of Allocations to permit NOVA-C uplink operations in this band, which are necessary to the success of the IM-1 Mission.

b. 2200-2290 MHz Band (Downlink)

The Table of Allocations allocates the 2200-2290 MHz band to various Federal uses on a primary basis, including space operation, Earth exploration-satellite service, fixed, mobile, and space research uses.[9] The band is not currently allocated to non-Federal uses.[10] As detailed

[7] *See* 47 C.F.R. § 2.106.

[8] *See id.*, n.US347.

[9] *See* 47 C.F.R. § 2.106.

[10] *Id.*

below, Intuitive Machines requests a waiver of the Table of Allocations to the extent necessary to downlink critical telemetry data from the NOVA-C, as well as payload data from Federal government and commercial payloads.[11]

c. *5.5-5.85 GHz Band* (Short-Range Lunar Communications)

The SPACEBIT Rover and EagleCAM payload will communicate with the NOVA-C via conventional 802.11ac in the 5.5-5.85 GHz band over a few tens of meters for data transfer. As noted above, the transceiver on the NOVA-C is a commercially available WPEQ-450AC radio with a Qualcomm chipset installed in the EagleCAM payload housing. The SPACEBIT Rover and EagleCAM each have their own commercially available QCA9008-TBD1 radios to enable communication with NOVA-C. All such radios are 802.11ac-compliant. Peak power of this proximity link is approximately 17 dBm and data rates are between 54-300 Mbps.

The 5 GHz communications between EagleCAM and the NOVA-C will commence at or within 30 meters of lunar surface and will be discontinued when all images are transferred to the NOVA-C. The 5 GHz communications between SPACEBIT and the NOVA-C will commence later for surface operations. The data will be relayed to Earth by the NOVA-C through the channels and emission designators in S-band, as noted above.

Use of this band is governed under 47 C.F.R. § 15, Subpart E of the Commission rules, classified within Unintentional National Information Infrastructure ("U-NII") devices. Since the range of communications will be limited to a few tens of meters *on the lunar surface only*, no interference issues with Earth-based communications are presented.[12]

[11] LN-1 is a NASA payload operating at 2256.3 MHz. Intuitive Machines understands that NASA is seeking separate authorization for use of this band.

[12] Intuitive Machines understands the use of these bands to be governed by 801.11ac standard and therefore do not require separate licensing by the Commission.

3. Small Spacecraft Licensing Criteria

Intuitive Machines is providing information pursuant to the Commission's streamlining small satellite licensing order[13] to ensure the Commission has a comprehensive understanding of the IM-1 Mission and the NOVA-C. Section 25.123 of the Commission's states that applicants filing under the streamlined rules must certify that they meet certain criteria.[14] Table 3 identifies the streamlined rules criteria and certifies that Intuitive Machines meets the criteria or will otherwise request a waiver.

Table 3: Small Spacecraft License Criteria

47 C.F.R § 25.123(b) Criteria	Compliance
(1) The space station(s) will operate and be disposed of beyond Earth's orbit	The NOVA-C will be deployed into a lunar orbit, land and remain on the lunar surface post-mission.
(2) The total lifetime from deployment to spacecraft end-of-life for any individual space station will be six years or less	The NOVA-C lifetime will last approx. 21 days, including a 7-day transit from Earth, followed by a 14 day stay on the lunar surface. Operation during the subsequent lunar day up to day 60 is possible if the NOVA-C's batteries survive lunar night.
(3) Each space station will be identifiable by a unique signal-based telemetry marker distinguishing it from other space stations or space objects	Intuitive Machines certifies that the NOVA-C will be uniquely identified by the proper telemetry signal.[15]
(4) The space station(s) will release no operational debris	Intuitive Machines certifies that the NOVA-C and its payloads will not release any operational debris.[16]
(5) No debris will be generated in an accidental explosion resulting from the conversion of energy sources on board the	Intuitive Machines certifies that the NOVA-C and payload design features mitigate the likelihood of such accidental explosions well below the 0.001 probability

[13] *See* Streamlining Licensing Procedures for Small Satellites, *Report and Order*, IB Docket No. 18-86, ¶ 65 (rel. Aug. 2, 2019) ("*Smallsat Order*") (noting that it is adopting its proposal "to allow small spacecraft with planned non-Earth orbiting missions, *such as commercial lunar missions*, to file under the streamlined process.") (emphasis added).

[14] *See* 47 C.F.R. § 25.123.

[15] *See* Attachment A, Technical Appendix, § A.15.

[16] *See* Attachment B, ODAR, § 3.

space station(s) into energy that fragments the spacecraft	requirement per NASA-STD-8719.14B as described in the ODAR assessment.[17]
(6) The probability of a collision between each space station and any other large object (10 centimeters or larger) during the lifetime of the space station is 0.001 or less as calculated using current NASA software or higher fidelity models	Intuitive Machines certifies that the probability of a collision sufficient to prevent compliance with the disposal plan is well below the required value of 0.001. Large Object Impact and Debris Generation Probability is 0.000000025.[18]
(7) Operation of the space station(s) will be compatible with existing operations in the authorized frequency band(s). Operations will not materially constrain future space station entrants from using the authorized frequency band(s)	Intuitive Machines will coordinate with NASA and other government agencies and seek a waiver of the Table of Allocations for non-interfering use of the 2025-2110 MHz band, as well as the 2200-2290 MHz band. Use of these bands is for an extremely limited duration and will not constrain current or future users of the band.
(8) The space station(s) can be commanded by command originating from the ground to immediately cease transmissions and the licensee will have the capability to eliminate harmful interference when required under the terms of the license or other applicable regulations	Intuitive Machines has complete command capability from its control center in Houston to cease transmissions to the NOVA-C.[19]
(9) Each space station is 10 cm or larger in its smallest dimension	Intuitive Machines certifies the NOVA-C is larger than 10 cm in its smallest dimension.[20]
(10) Each space station will have a mass of 500 kg or less, including any propellant	The NOVA-C's wet mass is approximately 1900 kg; therefore, Intuitive Machines is requesting a waiver of this provision.
(11) 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	Intuitive Machines will review conjunction warnings, coordinate physical operations of the NOVA-C with any operator using similar orbits, and, if necessary, mitigate collision risks to minimize operational impacts.[22]

[17] *See id.*, § 4.

[18] *See id.*, § 5.

[19] *See* Attachment A, Technical Appendix, § A.12.

[20] *See* Attachment B, ODAR, § 2.

[22] *See* Attachment B, ODAR, § 5.

warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.[21]	

Small spacecraft operating under the streamlined rules are exempt from the Part 25 processing round and default service requirements.[23] In lieu of the processing round rules, the Commission requires applicants to "(a) certify that operations of its satellites will not interfere with those of existing operators, (b) certify that it will not materially constrain future operators from using the assigned frequency band(s), and (c) provide a brief narrative description illustrating the methods by which both current and future operators will not be materially constrained."[24] Intuitive Machines certifies that the operations of the NOVA-C will not interfere with existing operators and that it will not materially constrain future operators from using the requested frequency bands.

In the *Streamlined Processing Order*, the Commission provided examples of applications that may satisfy the required description requirement. Potentially acceptable scenarios include those where the satellite operator possesses "a limited number of earth stations and downlinks during relatively short periods of time, with the ability to effectively schedule transmissions such that future satellite entrants can be accommodated."[25] As detailed in this application, the NOVA-C's limited operational time on discrete frequencies with a handful of earth stations mitigates the risk of interference. Moreover, Intuitive Machines will operate on an unprotected,

[21] *See* Applications for streamlined small spacecraft authorization, 85 Fed. Reg. 52452 (Aug. 25, 2020) (amending 47 C.F.R. § 123(b)). Out of an abundance of caution, Intuitive Machines certifies compliance with the amended regulation adding sec. 11, when effective.

[23] *Smallsat Order*, ¶ 80.

[24] *Id.*, ¶ 81.

[25] *Id.*

non-interference basis with respect to other authorized operators in the relevant bands. Intuitive Machines is also pursuing appropriate coordination with relevant stakeholders to ensure that no harmful interference to such operations will occur.

E. Ground segment

Communications to and from the NOVA-C will be conducted by the LTN, consisting of multiple dish antennas across the globe, including the 21-meter dish at Morehead State University Space Sciences Center in Kentucky.[26] Morehead State University has separately applied for Commission authorization to operate its earth station.

Reception of uplink (Earth-to-space) command and ranging transmissions by the NOVA-C will be via the Thales transceivers using low-gain antennas. Variable bandwidths encompass ranging-on and ranging-off modes as shown in the accompanying Schedule S.

Downlink (space-to-Earth) operations from the NOVA-C to the LTN include telemetry and data. Telemetry will be transmitted via Thales transceivers primarily on low-gain antennas, with a contingency use of the high-gain antenna. Data will also be transmitted via the Quasonix transmitter in up to 11 variable-rate bandwidths primarily using the high-gain antenna, with a contingency use of the low-gain antennas.

III. PUBLIC INTEREST STATEMENT

The IM-1 Mission represents one of the first missions in a new era of space exploration. As former NASA administrator Jim Bridenstine recognized, the Artemis program will enable "humanity … [to] explore regions of the Moon never visited before, uniting people around the unknown, the never seen, and the once impossible."[27] The program will bring humans back to

[26] *See* Attachment A, Technical Appendix, § A.10.1.

[27] *See Artemis Plan.*

the surface of the moon, including the first woman and person of color, within 4 years, and enable a long-term human presence on the moon by the end of the decade.[28]

A key enabler of this mission is the development of a regular commercial supply of materials and experiments to the Moon through the CLPS program. NASA selected Intuitive Machines to provide this service on behalf of NASA and other commercial payload operators. The payloads for this mission are essential to ensuring successful future landings by manned spacecraft, both on the Moon and beyond.

Grant of this application is fully consistent with the public interest by allowing Intuitive Machines to fulfill the objectives of the NASA CLPS program, providing unique and valuable scientific and engineering payloads to the lunar surface in early 2022. The IM-1 Mission will demonstrate complete lunar mission capabilities of science, exploration, and commercial development. These accomplishments and follow-on missions enabled by the IM-1 Mission will pave the way for humans returning to the Moon in 2024 and subsequent long-term settlement.

IV. OTHER MATTERS

A. Waiver Requests

The Commission may waive any of its rules if there is "good cause" to do so.[29] In general, waiver is appropriate if (i) special circumstances warrant a deviation from the general rule; and (ii) such deviation would better serve the public interest than would strict adherence to the rule.[30] Generally, the Commission will grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would

[28] *Id.*

[29] *See* 47 C.F.R. § 1.3; *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164 (D.C. Cir. 1990); *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

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

otherwise serve the public interest.[31] Good cause exists to waive the following rules under the special circumstances presented in this application.

1. U.S. Table of Frequency Allocations

a. 2025-2110 MHz

The 2025-2110 MHz band is allocated to Federal space research and other Federal uses on a co-primary basis with fixed and mobile commercial uses.[32] This band may be allocated to non-Federal Earth-to-space transmission in the space research service subject to such conditions as may be applied on a case by case basis, and the limitation that any use may not cause harmful interference to authorized Federal and non-Federal operations.[33] Intuitive Machines will coordinate with NASA and other Federal and non-Federal operators in this band to ensure the NOVA-C's operations will not cause harmful interference, consistent with the Commission's prior authorization of TT&C uplinks in this band.[34]

To the extent the Commission does not consider the NOVA-C's TT&C uplink operations to be permissible under the Federal space research allocation, Intuitive Machines hereby requests a waiver of the Table of Allocations to operate TT&C uplinks in this band. The use of the band is extremely limited (with a nominal mission lifetime of 21 days) and is intended for TT&C uplink operations only. Good cause exists to grant the requested waiver, and deviation from the rule would not undermine the contemplated protections to authorized users of the band.

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

[32] *See* 47 C.F.R. § 2.106.

[33] *See id.*, § 2.106, n.US347.

[34] *See, e.g.*, BlackSky Global LLC, File No. SAT-LOA-20180320-00023 (granted October 3, 2018) (granting application to operate in the 2025-2110 MHz band so long as such operations do not "cause harmful interference to stations operating in the 2025-2110 MHz band in accordance with the U.S. Table of Frequency Allocations.").

b. 2200-2290 MHz

Good cause also exists to grant waiver to TT&C and data downlink in the 2200-2290 MHz frequency band. This band is allocated to the space research service for Federal licensees,[35] and is allocated to space operations (space-to-Earth) and EESS (space-to-Earth) on a co-primary basis across all ITU regions. There is no current allocation for non-Federal users in the United States, and the NOVA-C will not be transmitting to TDRS systems.[36]

Nevertheless, Intuitive Machines is providing services on behalf of a government agency and is supported through Federal funding. Intuitive Machines will coordinate its proposed use with applicable Federal operators prior to use. The limited duration of the IM-1 Mission further mitigates the possibility of interference with Federal users. Additionally, Intuitive Machines will conduct its TT&C and data downlink operations in the 2200-2290 MHz band in the United States only on a non-interference/non-protection basis and only at a single earth station (Morehead, KY). All other downlink operations will occur outside the United States. Therefore, good cause exists to grant a waiver of the U.S. Table of Frequency Allocations in the event the Commission concludes that NOVA-C operations in the band are not permissible under the Federal space research allocation.

c. 5 GHz, 802.11ac Wi-Fi Standard

The SPACEBIT Rover and EagleCAM payloads will communicate with the NOVA-C via short range conventional Wi-Fi 802.11ac, classified under U-NII. In the event the Commission determines these payloads do not meet the requirements of the U-NII, Intuitive Machines respectfully requests the grant of a waiver for such use. The payloads will operate at

[35] *See* 47 C.F.R. §§ 2.102(a), 2.106.

[36] *See id.*, n.US303.

lower power levels than conventional Wi-Fi 802.11ac equipment, have a range of only tens of meters, and will operate only on or near the lunar surface. Therefore, there is no probability of interference from the proposed 5 GHz operations to any other device.

2. Waiver of Section 25.202(f) for Emission Limits

Section 25.202(f) provides for emissions limits attenuated according to the schedule set forth in subsections (f)(1)-(3). Intuitive Machines hereby requests a limited waiver of 25.202(f)(1)-(3) to the extent necessary to permit operation of the Quasonix transmitter.

Waiver is appropriate in this case as the circumstances of this application are unique and a waiver does not undermine the basis for the rule. The Quasonix transmitter's excursion beyond the limits set in Sections 25.202(f)(1)-(3) is small.[37] The anticipated pathloss of the Quasonix transmitter from the Moon to any potential victim receiver would be substantial, mitigating the risk of interference. Moreover, the limited use of 60 days or less under this license further reduces the chance of harmful interference to Federal operators. Considering these unique circumstances, a waiver is necessary to ensure operations of the NOVA-C.

The primary motivation for the emission limitation requirement is to ensure out-of-band emissions do not cause harmful interference to incumbent operators. Intuitive Machines is coordinating its operations with the relevant Federal incumbents to ensure no harmful interference will occur and, therefore, the intent of the rule will be preserved. In addition, a waiver of Sections 25.202(f)(1)-(3) would not affect Commission discretion set forth in paragraph 25.202(f)(4) to address interference concerns, consistent with Commission

[37] *See* Attachment A, Technical Appendix, § A.14.

precedent.[38] In view of the foregoing, good cause exists for a limited waiver of Sections 25.202(f)(1)-(3) and such a waiver would be consistent with the public interest.

3. Waiver of Section 25.202(g)(1) for TT&C Operations in the 2025-2110 MHz band

Section 25.202(g)(1) anticipates that satellite systems will conduct TT&C operations using spectrum at the edge of or within their assigned bands.[39] Intuitive Machines proposes to conduct uplink (Earth-to-space) command and ranging transmissions centered at 2035.59416 MHz – spectrum in which non-Federal transmissions may be authorized on a case-by-case basis and on a non-harmful interference basis.[40] Intuitive Machines intends to operate on this basis and will use the spectrum command and ranging uplinks to the NOVA-C for a limited period of time.

Waiver of this rule is appropriate due to the time-limited, pre-coordinated, unprotected, non-interfering operations of the NOVA-C. Accordingly, such a waiver would serve the public interest.

4. 47 C.F.R. § 25.123(b)(10)

Intuitive Machines also requests a waiver of the requirement that the wet mass of the NOVA-C will not exceed 500 kg. The wet mass of the NOVA-C will be 1908 kg and the dry mass is 624 kg. Waiver is appropriate and necessary in this case given extremely short-term use of the NOVA-C and the fact that it is non-Earth orbiting commercial lunar mission. Waiver in

[38] Paragraph 25.202(f)(4) provides that when emissions outside of the authorized bandwidth cause harmful interference, the Commission may require attenuation to levels below the limits specified in Subsection 25.202(f); *see also* Motorola Satellite Communications, Inc. Modification of License, *Order and Authorization*, DA 96-1780, ¶ 20 (rel. Oct. 30, 1996) (granting a waiver of Section 25. 202(f) and reserving authority in paragraph (f)(4)).

[39] *See* 47 C.F.R. § 25.202(g)(1).

[40] *See id.*, § 2.106, n.US347.

this instance will also support the availability of a regulatory pathway for authorizing smaller, non-Earth orbiting spacecraft and specifically U.S.-sponsored lunar missions.[41]

Although the Commission adopted a 500 kg "wet" mass limit, the figure has limited applicability to non-Earth orbiting spacecraft.[42] Indeed, the Commission acknowledged that it would consider revisiting certain restrictions on spacecraft applying under the streamlined process "in the future once we have additional experience authorizing these missions."[43]

The particular facts of the IM-1 mission make strict compliance inconsistent with the public interest.[44] The NOVA-C represents the first lunar mission seeking to use this regulatory pathway, and it is critical that the Commission recognize the need for licensing provisions that accurately reflect the legitimate mass requirements of non-Earth orbiting systems, especially given propellant requirements. A waiver of the mass requirement in this instance is necessary to fulfill the significant public interest objectives of the IM-1 Mission and the larger Artemis project. Considering these special circumstances and the public interest benefits of the IM-1 Mission, deviation from the Commission's small spacecraft mass limitation is necessary and appropriate to grant Intuitive Machines authority to operate the NOVA-C.[45]

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[41] *See Smallsat Order*, ¶ 65 ("We adopt the *NPRM* proposal to allow small spacecraft with planned non-Earth orbiting missions, such as commercial lunar missions, to file under the streamlined process").

[42] Given the limited sample size of non-earth orbiting spacecraft applications, it is not clear that 500 kg is an appropriate metric for determining if the a given spacecraft is "small" in the first instance. *See id.*, ¶ 66 (providing only that the FCC "modify the mass certification to specify a maximum mass for these spacecraft, including fuel, of 500 kilograms. … consistent with the comments we received suggesting that we adopt a higher mass limit for non-Earth-orbiting small spacecraft systems."). Nevertheless, while Commenters suggested the 500 kg limit as being better than the 180 kg limit proposed for Earth-orbiting satellites, commenters also noted that commercial lunar spacecraft generally include significant amounts of fuel which should not count towards any mass limit. Moreover, each commenter suggests 500 kg without providing any basis for why it is an appropriate limit. *See generally* Commercial Spaceflight Federation Comments at 9, Moon Express Comments at 2; and CSSMA Comments at 14-15.

[43] *Smallsat Order*, ¶ 67.

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

[45] *See id.*; *see also WAIT Radio*, 418 F.2d at 1159.

B. NOAA Authorization

The NOVA-C has cameras onboard that may point towards the Earth during LTO, including (i) EagleCAM which will be deployed and separated from the NOVA-C during landing, taking pictures as it tumbles to rest on the surface; (ii) SCALPSS which will capture video and still image data of the NOVA-C's plume as it impacts the lunar surface; (iii) ILO-X telescope for imaging the arm of the Milky Way galaxy; and (iv) two additional cameras for press releases. Intuitive Machines is engaged with the Commercial Remote Sensing Regulatory Affairs ("CRSRA") office at the National Oceanic and Atmospheric Administration ("NOAA") regarding these remote sensing applications. Intuitive Machines recognizes that grant of a NOAA authorization to operate a commercial remote sensing system may be required to authorize the NOVA-C and commits to work with NOAA and other U.S. Government stakeholders as needed to ensure that the NOVA-C complies with U.S. commercial remote sensing requirements.

FCC and NOAA licensing authorities overlap with respect to operation of remote sensing instruments. NOAA has authority to authorize operation of a commercial (private) remote sensing system under the National and Commercial Space Programs Act.[46] However, the Commission retains authority to authorize the launch and operation of the satellite system and the use of spectrum. Intuitive Machines acknowledges that implementation of NOVA-C will be contingent on successful conclusion of the FCC and NOAA processes.

C. Amended Small Spacecraft Rules

Out of an abundance of caution, Intuitive Machines is also providing a statement consistent with the Commission's amended small spacecraft rules, although the amended rules

[46] 51 U.S.C. § 60121 et seq.

are not yet effective. In particular, amended Section 25.122(d)(4) and (d)(6) are relevant to NOVA-C operations.[47] Section 25.122(d)(4) requires a description of design and operational strategies used to minimize the risk of collision with inhabitable spacecraft if the mission transits through the inhabited spacecraft's orbit. Although orbital parameters are very different, the NOVA-C will cross the altitudes of several satellites, including the ISS on its way to the Moon. Launch clearing analysis will be performed by the launch provider and, while the extent of debris avoidance concept of operations is to be determined, the NOVA-C has propulsive capability which will enable it to avoid such inhabitable spacecraft.

Likewise, the NOVA-C is fully compliant with amended Section 25.122(d)(6). As certified above, the NOVA-C will be uniquely identified by the proper telemetry signal.[48] Moreover, Intuitive Machines is registered with Space Track via the 18th SPCS for reporting of orbit data. Thus, even under the Commission's amended but not-yet-effective small spacecraft rules, the IM-1 Mission is compliant.

D. ITU Compliance

Intuitive Machines has prepared the International Telecommunication Union ("ITU") Advance Publication Information submission for its proposed system and is contemporaneously providing this information to the Commission under separate cover. Consistent with Section 25.111(d) and (e) of the Commission's rules, Intuitive Machines is also providing a declaration of unconditional acceptance of all consequent ITU cost-recovery charges to the Commission.[49]

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[47] *See* Applications for streamlined small spacecraft authorization, 85 Fed. Reg. 52452 (Aug. 25, 2020) (amending 47 C.F.R. § 122(d) which is made applicable to small spacecraft through 47 C.F.R. § 25.122(c)).

[48] *See* Attachment A, Technical Appendix, § A.15.

[49] *See* Attachment C, ITU Cost Recovery Letter; *see also* 47 C.F.R. § 25.111(d)-(e).

V. CONCLUSION

For the foregoing reasons, and for the reasons set forth in the accompanying materials, Intuitive Machines requests that the Commission expeditiously grant Intuitive Machines operating authority for the IM-1 Mission, including the NOVA-C and its payloads, consistent with the public interest.