

**Before the
Federal Communications Commission
Washington, DC 20554**

In the Matter of

Intuitive Machines, LLC

Amendment to Application for
Authority to Launch and Operate
the NOVA-C Lunar Lander

Call Sign: S3084

File Nos. SAT-LOA-20210423-00055,
SAT-AMD-_____

APPLICATION AMENDMENT

Intuitive Machines, LLC (“Intuitive Machines”) submits this amendment to its pending application for authority to launch and operate the NOVA-C lunar lander.¹ The amendment includes submission of an updated Schedule S with new power flux density (“PFD”) values associated with the NOVA-C lander’s telemetry downlink transmissions resulting from a change in launch profile. This amendment also includes a further explanation of the updated PFD analysis, as well as additional information regarding the *de minimis* potential for interference from the NOVA-C lunar lander’s telemetry operations and supporting its initial waiver request associated with such operations. As a result, this amendment supersedes the information originally submitted by Intuitive Machines in its application and supplements subsequent filings relating to the PFD levels of its telemetry carrier.

I. DISCUSSION

Subsequent to the filing of the original application for authority to launch and operate the NOVA-C lunar lander, Intuitive Machines provided additional clarification to its waiver

¹ See Intuitive Machines, LLC, IBFS File No. SAT-LOA-20210423-00055, Call Sign S3084 (“Intuitive Machines Application”).

request, which was associated with a temporary exceedance of PFD values in ITU Radio Regulation Article 21, Table 21-4, by the spacecraft's low data-rate telemetry downlinks.² Intuitive Machines also provided information accounting for a change in the mission's launch profile to utilize a direct-throw, trans-lunar injection burn.³

Given the changes to the NOVA-C's operations as described in the July 22nd Letter, the Commission requested that the Schedule S information be updated for downlink operations during the period following trans-lunar injection in which the PFD values exceed values set forth in ITU Radio Regulation Article 21.16, Table 21-4.⁴ Additionally, since that time, Intuitive Machines has refined its analysis of the PFD levels associated with the telemetry carrier. Specifically, Intuitive Machines has further assessed the power levels of the carrier using both the 4 kHz reference bandwidth in Table 21.4, as well as the more appropriate standard (applicable to space operations using a 1 MHz reference bandwidth) in ITU-R Recommendation SA.1273.⁵ This amendment provides an updated Schedule S, PFD analysis, and additional information supporting the waiver requested in this application proceeding.

A. Telemetry Carrier PFD Levels and 4 kHz Reference Bandwidth

Intuitive Machines has continued to analyze the characteristics of the NOVA-C's low data-rate telemetry carrier. The PFD levels reported in the original Schedule S considered output power concentrated strictly within the core bandwidth of the primary carrier, ignoring

² See *id.*

³ See Intuitive Machines, LLC, Submission pursuant to Section 1.65 of the Commission's Rules, IBFS File No. SAT-LOA-20210423-00055 (Call Sign S3084) (July 22, 2021) at B and C ("July 22nd Letter").

⁴ See Letter from Karl Kensinger, Satellite Division, to John Graves, Intuitive Machines, File No. SAT-LOA-20210423-00055 (March 2, 2022).

⁵ See Intuitive Machines, LLC, Submission pursuant to Section 1.65 of the Commission's Rules, IBFS File No. SAT-LOA-20210423-00055 (Call Sign S3084) (March 28, 2022) at Nos. 1 and 2 ("March 28th Letter").

power components extant among sub-carriers. Distributing power among sub-carriers by more accurately representing the signal structure with Bessel functions shows that the original values for PFD levels at the surface of the Earth were overly conservative by ~2 dB at both nadir and horizon.⁶ This results in worst-case PFD levels of approximately -120 dBW/m²/4 kHz (nadir) and -133 dBW/m²/4 kHz (horizon) at spacecraft separation.

Figures 1 and 2, below, illustrate both the original and revised PFD levels considering sub-carrier distribution, referenced to ITU Radio Regulation Article 21, Table 21-4. (Square traces indicate current values; circular traces indicate the ~2 dB lower values.)

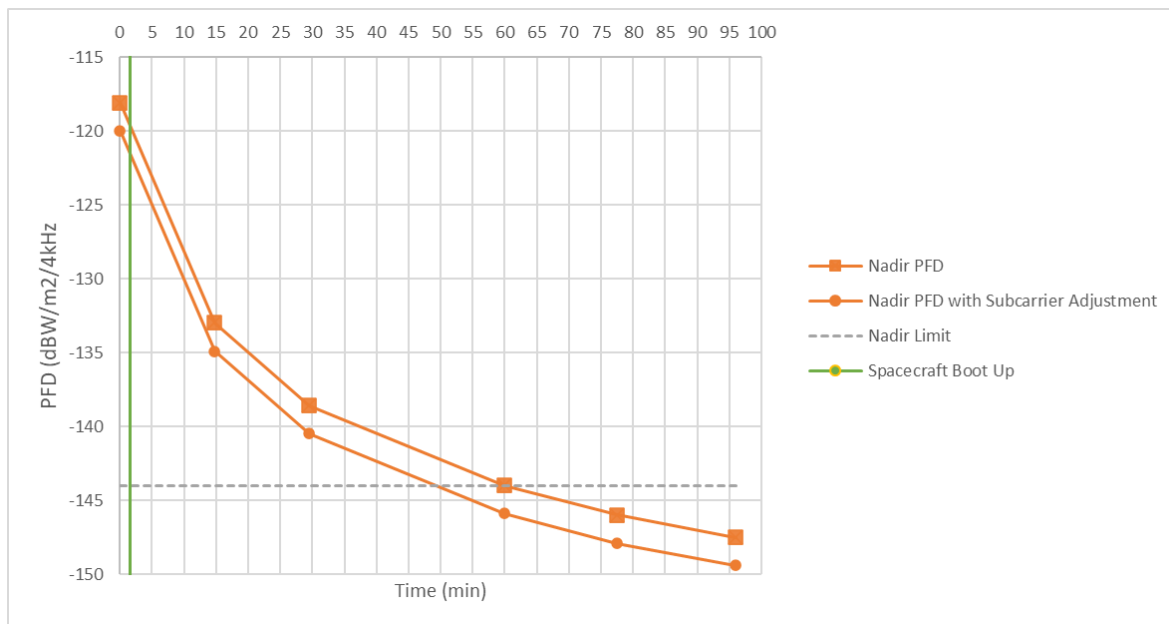


Fig. 1 – PFD Levels, Original and Revised Values (Nadir)

⁶ See Ziemer, R., Tranter, H. “Principles of Communications: Systems, Modulation, and Noise” (2015).

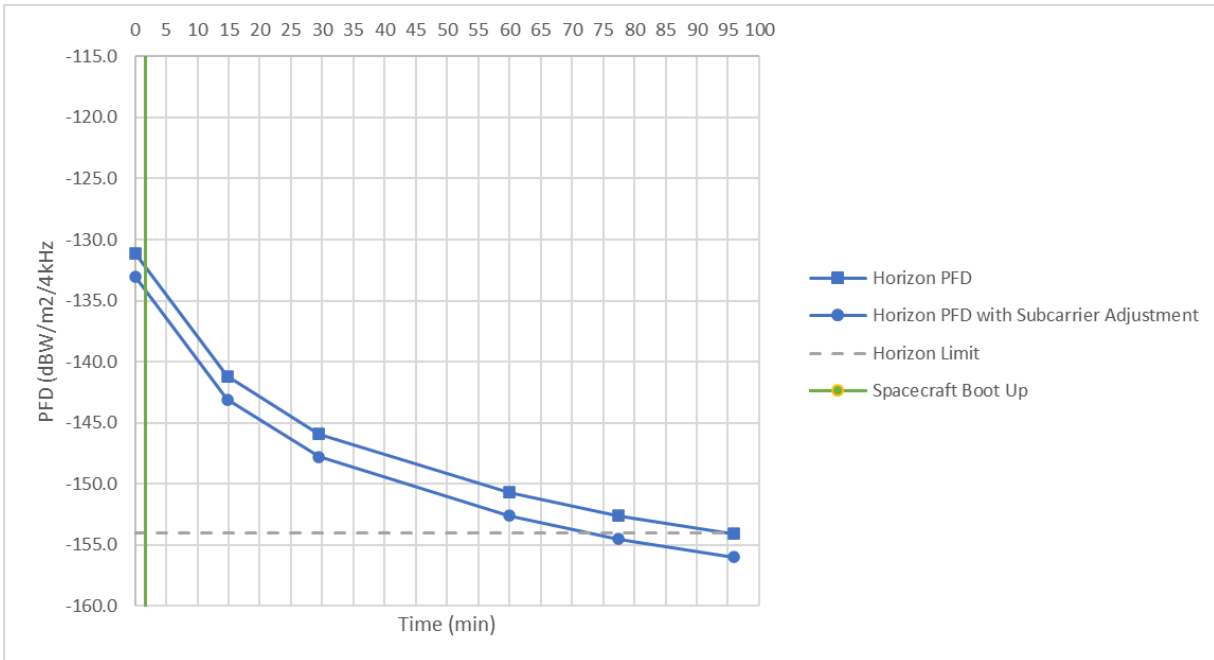


Fig. 2 – PFD Levels, Original and Revised Values (Horizon)

The foregoing reduction in PFD levels considering sub-carrier distribution is accompanied by a reduced exceedance time – approximately 18% and 20% less time for nadir and horizon, respectively, relative to Table 21-4 limits. In addition, telemetry transmissions will not begin until approximately 1.7 minutes after spacecraft separation (green line), further reducing prospective exceedance time when strictly applying the values and 4 kHz reference bandwidth of Table 21-4.

Intuitive Machines also notes PFD modeling analyses in NTIA Report 84-152.⁷ Although dated, the NTIA Report is still referenced today to understand practical interference impacts of GSO and NGSO satellite operations on fixed and mobile systems and assesses PFD levels using a 4 kHz reference bandwidth. The NTIA Report takes into account, among other factors, the fading of radio signals during propagation and effects on both analog and digital

⁷ NTIA Report 84-152, “Assessment of Satellite Power Flux-Density Limits in 2025-2300 MHz Frequency Range Part II” (July 1984), (“NTIA Report”) available at <https://www.ntia.doc.gov/legacy/osmhome/reports/rpt84152/index.html>.

terrestrial receivers. The results of the modeling in the NTIA Report led to a number of conclusions regarding PFD values from GSO and NGSO satellites, namely a 10-16 dB relaxation of applicable PFD values without increasing the potential to adversely affect terrestrial systems. Specifically, the NTIA Report recommended that PFD limits be relaxed from -144 to -134 dBW/m²/4 kHz (nadir) and from -154 to -144 dBW/m²/4 kHz (horizon) for GSO satellites. An additional 6 dB relaxation was allowed for “low orbit” satellites.⁸ The report differentiates between GSO and NGSO satellites, referring to the latter simply as “low orbit satellites,” with no specific altitude definitions.⁹ At NOVA-C separation from the launch vehicle, the altitude is still conventionally considered “low orbit.” Although the NTIA Report conclusions are applicable in the United States, they are recommended for review by other administrations.¹⁰

The experimental license application of Orbital Sciences (now Northrop Grumman) referenced the NTIA Report to support PFD exceedances of the Cygnus cargo spacecraft during downlinks from the International Space Station.¹¹ Intuitive Machines understands that similar exceedances have been permitted in the context of SpaceX’s Dragon capsule operations.¹² The long-time exceedances permitted in these experimental authorizations appear to be within the levels identified in the NTIA Report. In Intuitive Machines’ case, the temporary exceedance of the NOVA-C telemetry signal will exceed the levels identified by NTIA for only a few minutes.

Figures 3 and 4 show Intuitive Machines’ updated PFD levels relative to the NTIA Report’s recommended PFD values. (Square traces represent original PFD values; circular

⁸ See *id.*, Specific Conclusions No. 4.

⁹ See *id.*, Preliminary Discussions.

¹⁰ See NTIA Report, Section 2, at Introduction.

¹¹ See Orbital Sciences Corp., OET File No. 1465-EX-ST-2019, Call Sign WO9XD, at Attachment 1.

¹² See Space Exploration Technologies Corp., OET File No. 0582-EX-ST-2021, Grant at Condition 7.

traces represent ~2 dB improved values.) Taking the ~2 dB reduction into account reduces the exceedance time to approximately only 7 minutes. This represents a roughly 88% and 93% reduction in exceedance times for nadir and horizon, respectively, relative to Table 21-4 limits.

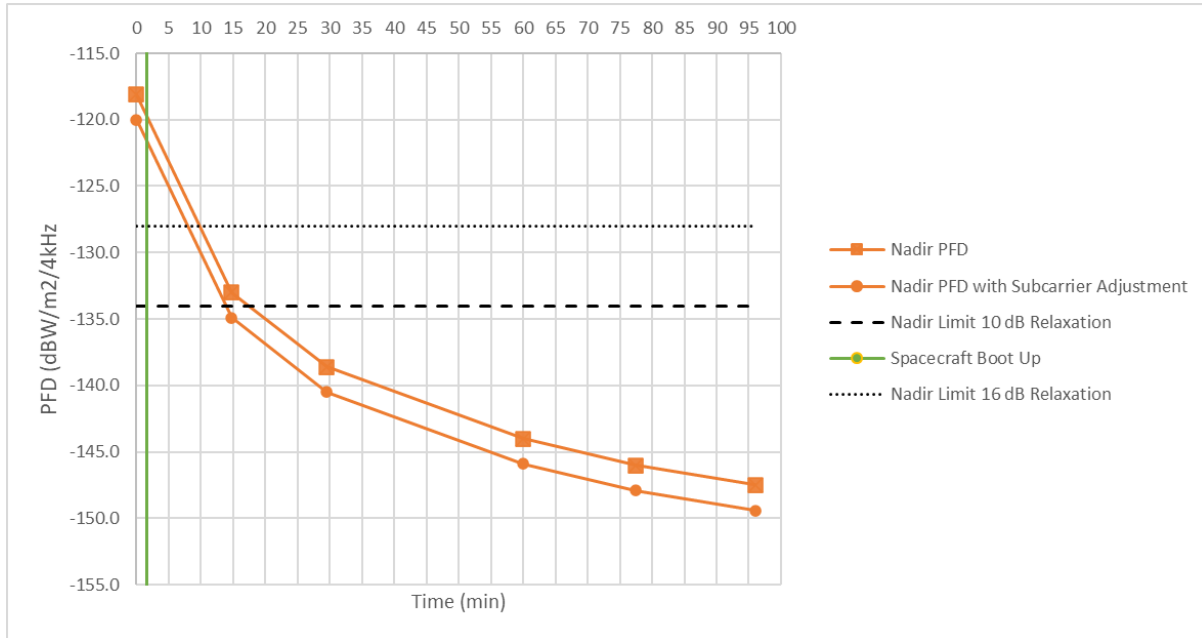


Fig. 3 – PFD Levels, Original and Revised (Nadir)

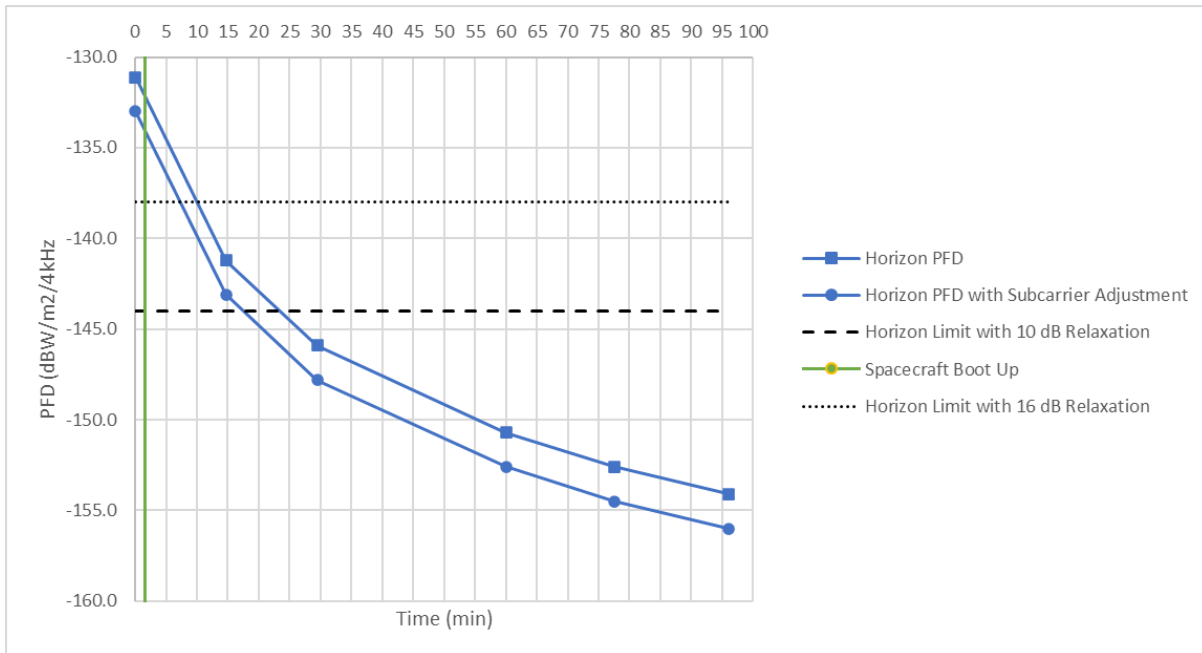


Fig. 4 – PFD levels, Original and Revised (Horizon)

B. ITU-R Recommendation SA.1273 and 1 MHz Reference Bandwidth

Intuitive Machines acknowledges the general applicability of the PFD limitations for space-to-Earth communication in the 2200-2290 MHz band set forth in Table 21-4 and the relaxation contemplated in the NTIA Report, but also notes that more recent international assessment of the permissible PFD levels for space operations may be the most appropriate levels to apply in the context of Intuitive Machines' telemetry downlinks. Specifically, ITU-R Recommendation SA.1273 includes less stringent limitations for critical space operations in the 2200-2290 MHz band of $-120 \text{ dBW/m}^2/1 \text{ MHz}$ (nadir) and $-130 \text{ dBW/m}^2/1 \text{ MHz}$. Although not mandatory, ITU-R recommendations are approved by ITU Member States, included in the ITU Radio Regulations, and are generally followed because they have been developed by experts from national administrations and industry.

Reference to ITU-R Recommendation SA.1273 and its 1 MHz reference bandwidth is appropriate because both the 250 kHz telemetry link at issue and potential victim terrestrial links are far wider than the 4 kHz reference bandwidth embodied in Table 21-4. The recommendation includes less stringent PFD levels given this ameliorating factor, as well as channel occupancy and satellite transmission activity. Intuitive Machines' consultations with NASA also confirm that use of the wider reference bandwidth is appropriate in such circumstances. Furthermore, NASA's pre-coordination efforts with U.S. government agencies and partner space agencies have revealed no interference concerns associated with the PFD levels of the telemetry carrier during the brief period following launch vehicle separation.

Figure 5, below, shows that the telemetry downlink PFD levels are compliant with ITU-R Recommendation SA.1273 at all times. (Dashed orange and blue lines represent the PFD limits for nadir and horizon, respectively; circled orange and blue plots represent the downlink PFD values

for nadir and horizon, respectively; telemetry transmissions commence approximately 1.7 minutes after separation from the launch vehicle (green line)).

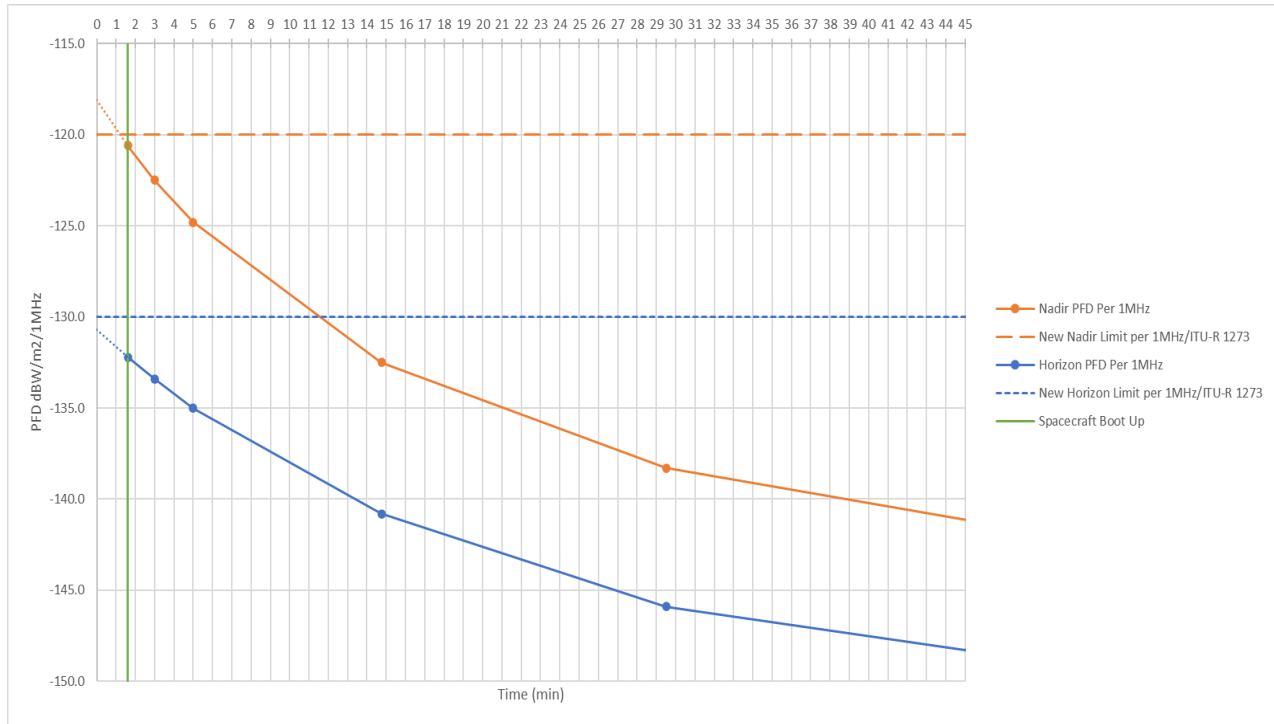


Fig.5 – PFD Values for Nadir and Horizon, ITU-R Recommendation SA.1273

C. Waiver Request

As discussed in the July 22 Letter, Intuitive Machines seeks to clarify and reiterate its request for a waiver of Section 2.106 of the Commission’s rules to permit the NOVA-C to operate telemetry downlinks with a center frequency at 2210.6 MHz. Intuitive Machines clarifies that its requested waiver of Section 2.106 of the Commission’s rules includes short-term operation of telemetry downlinks at higher PFD levels than contemplated by the ITU Radio Regulations during the brief period the spacecraft is near the Earth. The limited duration, geographic area, and frequency of the NOVA-C’s operations would facilitate coordination with incumbent U.S. government operators and others who may be impacted by a short-term PFD exceedance, and Intuitive Machines will continue to coordinate such downlink operations with

NASA and other relevant government agencies. Therefore, grant of the requested waiver will not result in harmful interference.

The Commission may waive any of its rules if there is “good cause” to do so.¹³ 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.¹⁴ 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 otherwise serve the public interest.¹⁵

Good cause exists to waive Section 2.106 under the special circumstances presented herein. Launch and operation of the NOVA-C lander is a key inaugural development in NASA’s CLPS (Commercial Lunar Payload Services) program to promote commercial exploration and development of the Lunar environment. The mission will showcase a variety of novel technologies designed to establish a future permanent U.S. presence at the Moon.

Brief exceedance of the PFD values set forth in ITU Radio Regulation Article 21, Table 21-4 would not undermine policy objectives. These PFD limits contemplate long-term operations and communications on time scales far lengthier than those of the IM-1 mission, and the temporary nature of the exceedance mitigates against harmful interference. The geographic area potentially affected by the PFD exceedance is centered largely over the Indian Ocean region, with the initial exceedance focused on southern Africa and expanding to South Asia and

¹³ 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).

¹⁴ See *Northeast Cellular*, 897 F.2d at 1166.

¹⁵ See *WAIT Radio*, 418 F.2d at 1157.

Oceania as the PFD from the NOVA-C's telemetry signal reaches compliant levels.¹⁶ Intuitive Machines believes there is limited deployment of terrestrial systems that could potentially be affected and any potential impact is more appropriately assessed using ITU-R Recommendation SA.1273, with which Intuitive Machines complies.¹⁷

Strict adherence to Article 21, Table 21-4 limits would not recognize the fleeting nature of the exceedance and the implications of ITU-R Recommendation SA.1273. The benefits ultimately derived from U.S. lunar exploration apply to all mankind, whereas a waiver of Section 2.106 to permit brief operations at initially elevated but ultimately compliant PFD levels would have no material interference impact. As a result, waiver of the Commission's rules is warranted, especially in light of the historic magnitude of the IM-1 mission.

In view of the foregoing, Intuitive Machines respectfully submits that the Commission can reasonably conclude that there is no potential for harmful interference from the NOVA-C lander's telemetry downlinks and that grant of the requested waiver is in the public interest. If the Commission concludes that specific mitigation or consents may be necessary or appropriate to support such operations, Intuitive Machines will work diligently to ensure that such measures are implemented and that no harmful interference occurs.

II. CONCLUSION

Intuitive Machines has carefully examined ITU and U.S. guidance regarding appropriate PFD levels for space operations in the 2200-2290 MHz band. Such guidance seeks to avoid harmful interference and incorporate more accurate technical considerations such as wider reference bandwidths. Intuitive Machines also provides a more refined analysis associated with

¹⁶ See July 22nd Letter, Annex 1 at Figure 1.

¹⁷ See March 28th Letter at 2-3 and n.5.

the use of sub-carriers and more accurate downlink transmit commencement time which reduces the period of any prospective PFD exceedance. For the reasons set forth herein and in Intuitive Machines' original application, the Commission should grant authority for the IM-1 mission, including the NOVA-C lander's telemetry downlink operations, at the earliest practicable time.