



Cover Photo: NASA

# U.S. Leadership in Lunar Spectrum Policy

BY Shayna Gersten

**Over the next decade**, NASA and many commercial and international entities plan to send missions to the Moon. All of these missions will use spectrum to communicate with Earth. However, the international regulatory frameworks overseeing radio spectrum beyond Earth's orbits (such as "lunar spectrum") are underdeveloped, creating the potential for interference and disruptions to communications with missions on and in orbit around the Moon. Currently, the United States and International Telecommunication Union (ITU) are considering specific frameworks for coordinating and

regulating lunar spectrum use. Despite a lack of frameworks, as of January 12, 2024, the ITU has already received over 50 filings for lunar missions from 9 different countries.<sup>1</sup>

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<sup>1</sup> Oliver Hawkins and Peggy Hollinger, "The race to claim the Moon's airwaves", Financial Times, 1/13/25,

<https://www.ft.com/content/4de3dce6-f94e-4b1b-b4a0-380386b5836c>

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Notably, 2024 was the first year that filings from commercial operators outnumbered government space agencies. The U.S.-proposed framework emphasizes international cooperation and coordination in the development and operation of lunar communications in a shared spectrum environment.<sup>2</sup>

### **Q1: How and why are communications to and from the Moon currently regulated?**

**A1:** In the United States, spectrum -- including spectrum used for communicating between the Earth and Moon, as well as in lunar orbit and on the Moon's surface -- is regulated by the Federal Communications Commission (FCC), and the National Telecommunications and Information Administration (NTIA). The FCC manages spectrum allocation and licensing for commercial and non-federal entities, while the NTIA oversees spectrum for federal purposes like defense, public safety, and scientific research. While the FCC and NTIA regulate spectrum for entities under U.S. jurisdiction, frameworks for lunar uses are underdeveloped at both domestic and international levels. Since the FCC lacks comprehensive regulations for lunar spectrum use, it currently leverages its existing authority to issue short-term spectrum licenses through 47 CFR Part 5 (Experimental Radio Service) and 47 CFR Part 25 (Streamlined Small Spacecraft Authorization). Part 5 licenses are primarily intended for technology demonstrations that are non-revenue generating missions such as a mission to test a small lunar rover

with no commercially substantive payloads. Lunar lander companies such as Intuitive Machines<sup>3</sup> and Firefly Aerospace, which include many commercial payloads to help offset development costs, receive lunar spectrum licenses under the Part 25 Streamlined Small Spacecraft Authorization. This authorization is designed for missions beyond Earth orbit with a 500 kg mass limit. This weight restriction is incompatible with the actual mass required for lunar landers, requiring operators to routinely seek waivers. Additionally, future lunar rovers that are intended to serve as long-term, commercially viable lunar infrastructure would also exceed that mass limit. Furthermore, lunar lander applicants under the streamlined Part 25 category explicitly state the temporary nature of their missions in their applications. This explicit statement helps avoid asserting long-term claims to lunar frequency usage, particularly significant given the absence of substantive internationally recognized allocations for lunar spectrum. While companies are able to receive temporary short-term licenses that comply with existing U.S. regulations, it leaves companies aiming for long-term cislunar infrastructure development in a regulatory gray area, highlighting the need for the U.S., in coordination with international bodies, to establish long-term lunar spectrum frameworks to support sustained lunar and cislunar commercial activity.

For example, Lockheed Martin's subsidiary, Crescent Space, has attempted to file for a 15-year FCC license for its Parsec lunar communications system.<sup>45</sup> Additionally, Lockheed has applied for a blanket license to deploy 230 lunar stations for communications and data storage, though industry pushback exists against blanket applications that bypass individual frequency

<sup>2</sup> James Schier, Catherine Sham, Dennis Lee, Kedar Abhyankar, Karen Clothier, "International Coordination and Cooperation on Lunar Spectrum", NASA, 10/2024, [https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024\\_Ka-Band\\_LunaNet\\_Spectrum.pdf](https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024_Ka-Band_LunaNet_Spectrum.pdf)

<sup>3</sup> Intuitive Machines FCC License Public Notice, <https://docs.fcc.gov/public/attachments/DA-25-152A1.pdf>

<sup>4</sup> Crescent Space Homepage, <https://crescent.space.com/>

<sup>5</sup> <https://fcc.report/IBFS/SAT-LOA-20220218-00020>

approvals.<sup>67</sup> Due to the regulatory void, Lockheed has requested FCC waivers and urged the agency to grant licenses with conditional future compliance once lunar guidelines are established. Whether these requests will be approved before international standards are set remains uncertain.

Among other responsibilities, the ITU facilitates international coordination and global regulations on radio spectrum and satellite orbits, including spectrum use beyond Earth's orbits, including cislunar space and on the Moon. The ITU Radio Regulations (RR), updated every three to four years at the World Radiocommunication Conference (WRC), are legally binding rules for the ITU's 193 members. The last WRC in 2023 invited ITU Radiocommunication (ITU-R) Working Party 7B to conduct studies to determine future spectrum allocations for lunar space.<sup>8</sup> These studies will focus on developing rules for using spectrum in support of scientific and technical research activities on the lunar surface and for spacecraft in lunar orbit.<sup>9</sup> While the current focus is limited to missions dedicated to scientific or technical research purposes, this is a critical first step in creating a comprehensive lunar framework. Currently, lunar operations that are granted temporary FCC licenses are not entitled to protections from interference by other operations and must cease transmissions if they disrupt other operators.<sup>10</sup> Without explicit ITU allocations for lunar frequency bands, lunar space missions can still operate and be filed under ITU Radio Regulation Article 4.4 which states that one, "shall

cause no harmful interference to, and shall not claim protection from harmful interference caused by, a station operating in accordance with provisions of the RR."<sup>11</sup> Securing ITU lunar spectrum allocations and thereby ensuring international regulatory protections is crucial as the increase in lunar missions heightens the risk of interference.

Internationally binding Radio Regulations designate which portions of the frequency bands are allocated for specific purposes, ensuring efficient and interference-free communication. Delineating portions of the spectrum band for distinct operational uses such as lunar emergency beacons, lunar surface communications, or lunar surface-to-orbiter links to name a few is critical for establishing a reliable and deconflicted lunar communications environment.

The results from the ITU study will guide the first phase of shared lunar spectrum regulations, which will be addressed in 2027 at WRC-27.<sup>12</sup> Technical studies will occur in 2025, regulatory conditions will be developed in 2026, and in 2027 the new regulations and allocations will be signed in the ITU. Once the ITU finalizes spectrum allocations for lunar space, domestic frequency agencies, like the FCC, can confidently finalize and issue long-term spectrum licenses on and around the Moon, backed by international regulatory protections, frequency designations, and acknowledgments.

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<sup>6</sup>[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=23036041](https://licensing.fcc.gov/myibfs/download.do?attachment_key=23036041)

<sup>7</sup>[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=22718429](https://licensing.fcc.gov/myibfs/download.do?attachment_key=22718429)

<sup>8</sup> Cathy Sham, Dennis Lee, Karen Clothier, Kedar Abhyankar, International Spectrum Regulatory Recognition of Lunar and Cislunar Activities, NASA, <https://arc.aiaa.org/doi/10.2514/6.2024-4856>

<sup>9</sup> Resolution 680 (WRC-23) Studies on frequency-related matters, including possible new or modified space research service (space-to-space) allocations, for future development of communications on the lunar surface and between lunar orbit

and the lunar surface, ITU, [https://www.itu.int/dms\\_pub/itu-r/oth/0c/0a/ROCOA0000100015PDFE.pdf](https://www.itu.int/dms_pub/itu-r/oth/0c/0a/ROCOA0000100015PDFE.pdf)

<sup>10</sup> James Schier, Catherine Sham, Dennis Lee, Kedar Abhyankar, Karen Clothier, "International Coordination and Cooperation on Lunar Spectrum", NASA, 10/2024, [https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024\\_Ka-Band\\_LunaNet\\_Spectrum.pdf](https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024_Ka-Band_LunaNet_Spectrum.pdf)

<sup>11</sup>ITU RRs: <https://www.unoosa.org/pdf/icg/2015/presentations/43.pdf>

<sup>12</sup> Cathy Sham, Dennis Lee, Karen Clothier, Kedar Abhyankar, International Spectrum Regulatory Recognition of Lunar and Cislunar Activities, NASA, <https://arc.aiaa.org/doi/10.2514/6.2024-4856>

## **Q2: How are lunar communications coordinated internationally?**

**A2:** Today, there are several international fora in which countries try to coordinate on lunar spectrum such as the Space Frequency Coordination Group (SFCG), the Interagency Operations Advisory Group (IOAG), and the Consultative Committee for Space Data Systems (CCSDS). Among these, the SFCG has a leading role in advancing internationally developed shared lunar spectrum resolutions. This international technical body, comprising 32 member agencies, including major space agencies such as NASA, the European Space Agency (ESA), Russia's ROSCOSMOS, and the China National Space Administration (CNSA), operates with the ITU as an observer. Unlike the ITU, the SFCG was not established by treaty and is an informal forum, allowing space actors to reach nonbinding agreements on specific frequencies and technical issues.

In 2006, the SFCG established the Lunar Martian Spectrum Group (LMSG), which is chaired by a NASA representative who also leads the ITU-R subgroup in charge of testing lunar spectrum.<sup>13</sup> The LMSG is the main sub-group within the SFCG working on addressing both lunar and martian spectrum challenges, including developing and maintaining spectrum plans, addressing mission-specific requirements, and facilitating collaboration among space agencies. Since the ITU can only update its internationally binding Radio Regulations every three to four years, forums like the SFCG provide supplementary venues where space actors can hold international discussions and forge agreements at a pace more commensurate with advancements in space technology and mission timelines.

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<sup>13</sup> Lunar Spectrum Considerations, ICG-17 Plenary, NASA, Cathy Sham, 2023, <https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17.02.08.pdf>

<sup>14</sup> About the Lunar Spectrum Manager, NASA, <https://www.nasalsmp.org/SitePages/About-the-Lunar-Spectrum-Manager.aspx>

## **Q3: What actions is NASA taking?**

**A3:** NASA has developed a Lunar Spectrum Management Portal (LSMP) which acts as a voluntary international coordination point for planning lunar missions.<sup>14</sup> Originally created as an internal coordinating tool, the Space Frequency Coordination Group (SFCG) is now recommending its usage for lunar spectrum filing for all commercial and governmental space actors.<sup>15</sup> Previously, no pre-coordination process existed for commercial users unless they partnered with NASA, another U.S. government agency, or an international civil space agency. With the increase of commercial operators, the LSMP can provide a valuable coordination role between commercial and government users, ensuring a safer and more organized operating environment by offering tools for effective spectrum management like recommended frequency selection, interference analysis, and technical pre-coordination processes.<sup>16</sup>

Additionally, LunaNet, now being co-developed by NASA, ESA, and the Japan Aerospace Exploration Agency (JAXA), is an innovative approach to lunar communications standards in a shared spectrum environment. LunaNet operates as a 'network of networks', managed and co-developed by multiple organizations to deliver interoperable Communications, Position, Navigation, and Timing (CPNT) services to any user in the lunar region. Due to LunaNet's emphasis on interoperability, any company or organization can deploy a satellite or communication device in the lunar region and seamlessly integrate as a node within the network, thereby accelerating the network's rapid

<sup>15</sup> Resolution A40-1: Assistance in the Assignment of Frequencies to Missions in the Lunar Vicinity, SFCG, 2024, [https://www.sfcgonline.org/Resolutions/RES%20SFCG%20A40-1%20\(Assistance%20in%20the%20Assignment%20of%20Frequencies%20to%20missions%20in%20the%20Lunar%20Reg\).pdf](https://www.sfcgonline.org/Resolutions/RES%20SFCG%20A40-1%20(Assistance%20in%20the%20Assignment%20of%20Frequencies%20to%20missions%20in%20the%20Lunar%20Reg).pdf)

<sup>16</sup> Cathy Sham, Lunar Spectrum Considerations, 2024, <https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17.02.08.pdf>

expansion.<sup>17</sup> This framework is based on internationally agreed upon standards, protocols, frequency bands, and interface requirements, with shared spectrum usage as a founding principle.<sup>18</sup> It is expected that LunaNet will be expanded across the solar system as an interplanetary network.<sup>19</sup> LunaNet's current spectrum plan comprises X and Ka bands for Earth-Moon satellite communications, with possible optical links, and S and Ka bands for communications around the Moon as shown in Figure 1.<sup>20</sup> The distance between the Moon and Earth should ensure that S-band interference does not occur between lunar and terrestrial Earth use. Additionally, tests are scheduled to assess the establishment of a 3GPP type network on the lunar surface. The 3rd Generation Partnership Project (3GPP) develops global standards for mobile communications, including 4G, 5G, LTE, and other networking standards currently under development. Replicating frequency band designations that align with those already used in Earth networks allows operators to leverage existing, proven technology that can be easily space-hardened, reducing development costs for lunar deployment. Nokia and Intuitive Machines, for example, attempted to deploy the first lunar 4G/LTE cellular network in

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<sup>17</sup> James Schiera , Coralí Roura , Phillip Paulsenb, Karl Vadenb, Jennifer Rockb, Charles Sheeheb, Angela Peurac , Marc Seibertc , Erica Weir, Deeper Dive into Interoperability and Its Implications for LunaNet Communications and Navigation Services, NASA, June 28, 2024,

<https://ntrs.nasa.gov/api/citations/20240007403/downloads/Interoperability%20for%20LunaNet%20Services.pdf>

<sup>18</sup> Catherine G. Manning, LunaNet Interoperability Specification, Feb. 08, 2024, NASA, <https://www.nasa.gov/directorates/somd/space-communications-navigation-program/lunanet-interoperability-specification/>

<sup>19</sup> James Schier, Catherine Sham, Dennis Lee, Kedar Abhyankar, Karen Clothier, "International Coordination and Cooperation on Lunar Spectrum", NASA, 10/2024, [https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024\\_Ka-Band\\_LunaNet\\_Spectrum.pdf](https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024_Ka-Band_LunaNet_Spectrum.pdf)

<sup>20</sup> James Schier, Cathay Sham, Karen Clothier, Dennis Lee, Kedar Abhyankar, International Coordination and Cooperation On LunaNet Spectrum Deck, NASA, 2024, <https://ntrs.nasa.gov/api/citations/20240011969/downloads/International%20Coordination%20on%20LunaNet%20Spectrum.pdf>

<sup>21</sup> Nokia and Intuitive Machines deliver first cellular network to the Moon; achieve some key mission objectives, 2025, <https://www.nokia.com/about->

February 2025, but the mission encountered landing complications and Nokia only had 25 minutes of network connection to run tests before losing all power.<sup>21,22,23</sup> The IOAG, an international forum focused on interagency space communication standards and strategies to ensure interoperability among space agencies, is developing governance structures for LunaNet through its Committee to Study LunaNet Governance.<sup>24</sup> However, at a Lunar PNT meeting jointly held in February 2025 with the International Committee on Global Navigation Satellite Systems (ICG), a body within the United Nations Office of Outer Space Affairs (UNOOSA), the IOAG stated that establishing an official governance structure will take time.<sup>25</sup> One idea proposed was creating a new Secretariat position under UNOOSA in charge of LunaNet/Lunar Governance.<sup>26</sup> In the near term, NASA, ESA, and JAXA will form the Coordinated LunaNet Administration Partners for self-administering critical topics in CPNT and developing non-binding standards amongst space agencies and commercial actors.<sup>27</sup> These standards are intended to be co-developed and defined with input from the global scientific community and commercial industry under

[us/news/releases/2025/03/10/nokia-and-intuitive-machines-deliver-first-cellular-network-to-the-moon-achieve-some-key-mission-objectives/](https://www.nokia.com/about-us/news/releases/2025/03/10/nokia-and-intuitive-machines-deliver-first-cellular-network-to-the-moon-achieve-some-key-mission-objectives/)

<sup>22</sup>Nokia's Cellular Network Ready for Moon as Intuitive Machines Completes Final Lunar Lander Installation, 2025, <https://www.intuivemachines.com/post/nokia-s-cellular-network-ready-for-moon-as-intuitive-machines-completes-final-lunar-lander-installat>

<sup>23</sup> Cathy Sham, Dennis Lee, Karen Clothier, Kedar Abhyankar, International Spectrum Regulatory Recognition of Lunar and Cislunar Activities, NASA, <https://arc.aiaa.org/doi/10.2514/6.2024-4856>

<sup>24</sup> Committee to Study LunaNet Governance, IOAG, 2023, <https://www.ioag.org/Public%20Documents/Committee%20to%20Study%20LunaNet%20Governance%20ToR.pdf>

<sup>25</sup> Committee to Study LunaNet Governance, IOAG, 2023, <https://www.ioag.org/Public%20Documents/Committee%20to%20Study%20LunaNet%20Governance%20ToR.pdf>

<sup>26</sup><https://www.ioag.org/SitePages/Joint-ICG-IOAG-Multilateral-Cislunar-PNT-Workshop.aspx>

<sup>27</sup>[https://www.ioag.org/\\_layouts/15/WopiFrame.aspx?sourcedoc=%7B4BB19E35-E276-4A6F-B0D8-54C9265EA1D9%7D&file=01%20LunaNet%20for%20ICG-IOAG%20CisLun%20PNT%2011-13Feb2025v4.pdf&action=default](https://www.ioag.org/_layouts/15/WopiFrame.aspx?sourcedoc=%7B4BB19E35-E276-4A6F-B0D8-54C9265EA1D9%7D&file=01%20LunaNet%20for%20ICG-IOAG%20CisLun%20PNT%2011-13Feb2025v4.pdf&action=default)

the auspices of international organizations.<sup>28</sup> The IOAG and the Consultative Committee for Space Data Systems (CCSDS), both chaired by NASA representatives, have adopted LunaNet's founding SFCG-recommended frequencies as the optimal choice for lunar spectrum.<sup>29</sup> CCSDS is a multi-national forum that develops communications and data systems standards for spaceflight, ensuring interoperability among international space agencies and commercial operators. CCSDS essentially 'implements' the operational space communication requirements stemming from the IOAG.<sup>30</sup>

However, it remains to be seen whether China, who is planning a number of significant lunar missions, will abide by LunaNet standards. Despite this uncertainty, Beijing emphasized its desire for interoperability in a working group session on Lunar Position Navigation and Timing (PNT) back in June 2024 and again in February 2025. Notably, Beijing initially agreed with the United States on spectrum bands for use around the Moon and between the Earth and Moon; however, there are concerns that Beijing's recent lunar deployments could contradict this agreement, and that they may seek to reverse the decision within the SFCG, possibly testing their influence as a space superpower. Furthermore, at the ICG-IOAG Lunar PNT meeting in February 2025, multiple Chinese representatives mentioned utilizing both S-band and L-band for Lunar PNT.<sup>31</sup> Both the U.S. and the SFCG stated that S-band is the optimal choice for lunar PNT and not L-band which could cause harmful interference to radio astronomy observations in the Shielded Zone of the Moon (SZM), which are protected

<sup>28</sup>[https://www.ioag.org/\\_layouts/15/WopiFrame.aspx?sourcedoc=%7B838B241A-29D6-49F6-9D66-5604FF99D0A6%7D&file=03%20LunaNet%20Perspectives,%20Frame,%20Suzuna%20OKAMOTO%20\(JAXA\)\\_A.pdf&action=default](https://www.ioag.org/_layouts/15/WopiFrame.aspx?sourcedoc=%7B838B241A-29D6-49F6-9D66-5604FF99D0A6%7D&file=03%20LunaNet%20Perspectives,%20Frame,%20Suzuna%20OKAMOTO%20(JAXA)_A.pdf&action=default)

<sup>29</sup> CCSDS Blue Book of Recommended Standards Table 3-1: Recommended Frequency Bands for Communications in the Lunar Region, 2024, <https://public.ccsds.org/Pubs/883x0b2.pdf>

<sup>30</sup>[https://www.ioag.org/\\_layouts/15/WopiFrame.aspx?sourcedoc=%7BCBBE47E8-08DA-480E-B0E1-0365245CB8C2%7D&file=06%20CCSDS-LunarPNT-13-02-25.pdf&action=default](https://www.ioag.org/_layouts/15/WopiFrame.aspx?sourcedoc=%7BCBBE47E8-08DA-480E-B0E1-0365245CB8C2%7D&file=06%20CCSDS-LunarPNT-13-02-25.pdf&action=default)

<sup>31</sup>[https://www.ioag.org/\\_layouts/15/WopiFrame.aspx?sourcedoc=%7BA47F26D6-C27D-460E-B025-](https://www.ioag.org/_layouts/15/WopiFrame.aspx?sourcedoc=%7BA47F26D6-C27D-460E-B025-)

by ITU Radio Regulations. Although, in multiple presentations, Chinese representatives emphasized the desire for interoperable lunar PNT systems through standardization at national and international levels. Furthermore, when presenting on S-band PNT frequencies, Chinese representatives displayed the same S-band frequency listed by LunaNet's PNT Augmented Forward System (AFS), 2483.5 - 2500 MHz. Despite Beijing's statement to also study L-band as a PNT backup, CCSDS stated that they will be studying LunaNet's AFS as a potential standard for lunar PNT, further strengthening NASA's push for international LunaNet adoption.

NASA is also embedding compliance mandates in its commercial contracts for lunar missions. Contractors for the Lunar Communication Relay and Navigation System (LCRNS) must adhere to LunaNet standards, ensuring alignment with NASA's vision.<sup>32</sup> Companies like Intuitive Machines and Lockheed Martin's subsidiary Crescent Space are already agreeing to adopt these standards.<sup>33</sup>

### **Q3: What are the chances NASA's plans will be adopted internationally?**

**A2:** NASA's strategic use of contractual mandates and active role in international fora positions it to influence the establishment of global standards for lunar communications. Both ESA and JAXA have committed to abide by LunaNet for future lunar missions and mandate compliance for their commercial contractors, which will further strengthen this foundation.<sup>34</sup> ESA's Moonlight

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<sup>32</sup> LCRNS Lunar Relay Services Requirements, NASA, 2023, <https://sam.gov/api/prod/opps/v3/opportunities/resources/files/384128cc09134971b29c51d6b1256fb7/download?&status=archived&token=>

<sup>33</sup> LM/Crescent Lunar-Cislunar Services Overview, Lockheed Martin, June 2023, [https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=23036041](https://licensing.fcc.gov/myibfs/download.do?attachment_key=23036041)

<sup>34</sup> Cheryl Graming NASA, Juan Crenshaw NASA, Floor Melman ESA, Richard Swinden ESA, Masaya Murata JAXA, LunaNet: Interoperability for Lunar PNT, 2024, UNOOSA ICG, June 2024,

program, a European and Canadian industry consortium encouraging commercial development and control of lunar SATCOM, will be fully LunaNet compliant.<sup>35</sup>

Moonlight will deploy five satellites in-orbit around the Moon, four for navigation and one for communication, targeting the lunar south pole. After the initial Lunar Pathfinder satellite mission, ESA has committed to requiring LunaNet compliance in future contract proposals, ensuring that their commercial partners adhere to the same lunar spectrum usage standards.<sup>36</sup>

<sup>37</sup>Similarly, JAXA's Lunar Navigation Satellite System (LNSS) is designed to abide by LunaNet's frequency ranges.<sup>38</sup> LNSS will consist of eight relay orbiters providing GPS for the lunar south pole, with the first deployment scheduled to be built by the Japanese company Arkedge Space. The combination of NASA's, ESA's, and JAXA's planned lunar SATCOM deployments, built with LunaNet principles, should create a robust foundation for lunar communications infrastructure.

Future space actors, both commercial and governmental, should be influenced to adopt LunaNet principles, recognizing it as the most cost-efficient option since the foundational infrastructure will have been established. All three systems have a planned interoperability test demonstration scheduled for 2029 to prove to the industry the robustness of the LunaNet concept. NASA's shared lunar spectrum vision is also being adopted by international organizations, with the IOAG establishing a Committee to Study LunaNet Governance and the Consultative Committee for Space

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[https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_01.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_01.pdf)

<sup>35</sup>ESAs Moonlight Programme: Pioneering for Lunar Exploration, ESA, 2024, [https://www.esa.int/Applications/Connectivity\\_and\\_Secure\\_Communications/ESA\\_s\\_Moonlight\\_programme\\_Pioneering\\_the\\_path\\_for\\_lunar\\_exploration](https://www.esa.int/Applications/Connectivity_and_Secure_Communications/ESA_s_Moonlight_programme_Pioneering_the_path_for_lunar_exploration)

<sup>36</sup> US-ESA MOU Lunar Pathfinder, <https://www.state.gov/wp-content/uploads/2023/10/22-615-European-Space-Agency-Space-Lunar-Pathfinder-6.15.2022-TIMS-63201.pdf>

<sup>37</sup> Joint Concept of Operations for Cooperative Lunar Relay and Navigation, ESA-NASA, 2022, [https://www.nasa.gov/wp-content/uploads/2023/04/joint\\_con\\_ops\\_document\\_dec\\_14\\_2022\\_final\\_draft.pdf](https://www.nasa.gov/wp-content/uploads/2023/04/joint_con_ops_document_dec_14_2022_final_draft.pdf)

Data Systems (CCSDS) recommending LunaNet's founding SFCG frequencies in their Blue Book of Recommended Standards. CCSDS also created an annual LunaNet Developers Forum and a Lunar Interoperability Forum.<sup>39,40</sup> Additionally, the SFCG recommends NASA's LSMP as an international coordination point prior to filing for lunar spectrum and there are multiple frequency overlaps between LunaNet frequencies and those currently undergoing testing by

the ITU as shown in Table 1.<sup>41</sup> Furthermore, NASA continues to provide technical support for ITU lunar spectrum studies, with the results directly influencing

<sup>38</sup> Lunar Navigation Satellite System (LNSS) and Its Demonstration Mission, JAXA, 2022, [https://www.unoosa.org/documents/pdf/icg/2022/ICG16/WG-B/ICG16\\_WG-B\\_03.pdf](https://www.unoosa.org/documents/pdf/icg/2022/ICG16/WG-B/ICG16_WG-B_03.pdf)

<sup>39</sup> CCSDS LunaNet Developers Forum, <https://public.ccsds.org/meetings/2023Fall/DevForum.aspx>

<sup>40</sup> CCSDS Lunar Interoperability Forum, <https://public.ccsds.org/LunarForum.aspx>

<sup>41</sup> Resolution A40-1: Assistance in the Assignment of Frequencies to Missions in the Lunar Vicinity, SFCG, 2024, [https://www.sfcgonline.org/Resolutions/RES%20SFCG%20A40-1%20\(Assistance%20in%20the%20Assignment%20of%20Frequencies%20to%20missions%20in%20the%20Lunar%20Reg\).pdf](https://www.sfcgonline.org/Resolutions/RES%20SFCG%20A40-1%20(Assistance%20in%20the%20Assignment%20of%20Frequencies%20to%20missions%20in%20the%20Lunar%20Reg).pdf)

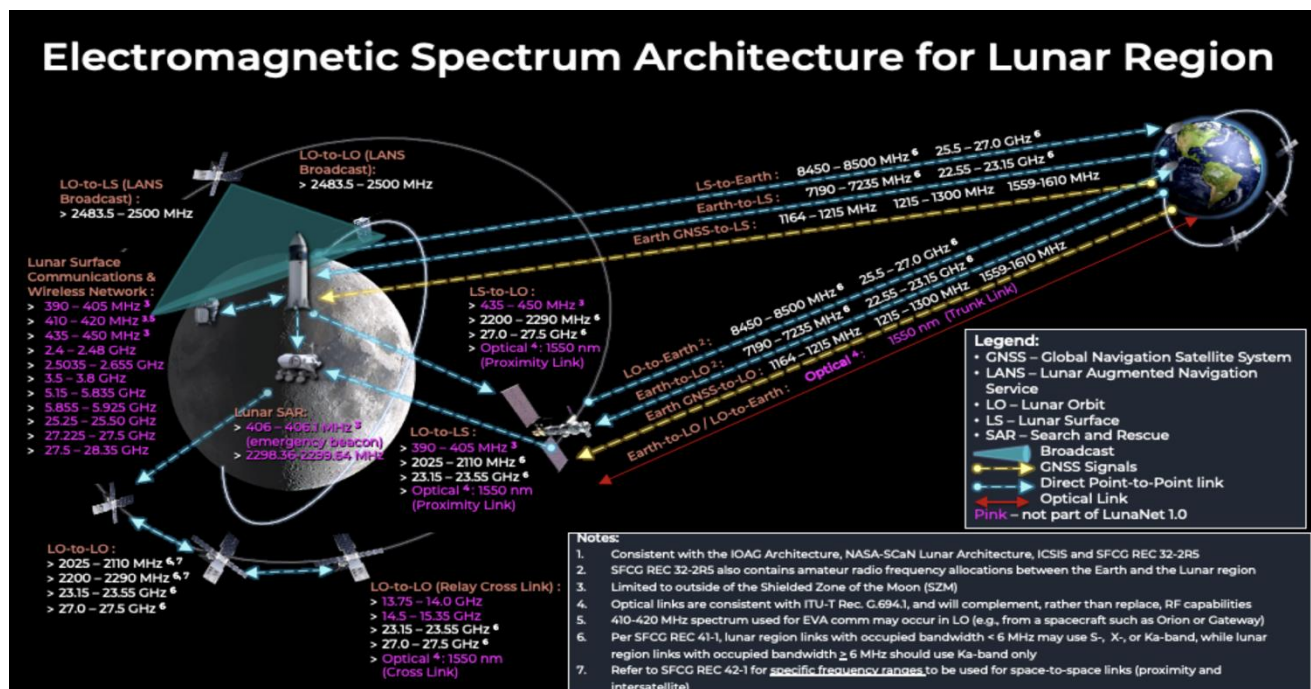
WRC-27 regulatory decisions, which will serve as the foundation for the FCC's eventual lunar framework.

The Moon will be the proving ground for all future space exploration, and the rules established during this next phase in space development will create a framework for human exploration across the entire solar system. It is imperative that a robust framework is set up based on internationally developed shared spectrum usage to ensure the success of all future space endeavors. ▶

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**Figure SEQ Figure 1\* ARABIC 1: Electromagnetic Spectrum Architecture for Lunar Region**  
 (Source: LunaNet Interoperability Specification Version 5, 2025, <https://www.nasa.gov/wp-content/uploads/2025/02/lunanet-interoperability-specification-v5-baseline.pdf?emrc=606f9>)





**Table 1: Lunar Spectrum Frequencies**

(Sources: (1) Lunar Spectrum Management Portal Recommended Frequency Bands, <https://www.nasalsmp.org/SitePages/Recommended-Frequency-Bands.aspx>, and (2) International Coordination and Cooperation on LunaNet Spectrum, NASA, 2024, [https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024\\_Ka-Band\\_LunaNet\\_Spectrum.pdf](https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024_Ka-Band_LunaNet_Spectrum.pdf))

Broad Lunar Spectrum Categories	SFCG Lunar Frequencies	Band	Selected for ITU Lunar Testing	LunaNet Frequencies
Earth to Lunar Orbit	2025-2110 MHz 7190-7235 MHz 22.55-23.15 GHz 40.0-40.5 GHz	S C K Ka	7190-7235 MHz	2025 – 2110 MHz 7190 – 7235 MHz 22.55 – 23.15 GHz
Lunar Orbit to Earth	2200-2290 MHz 8450-8500 MHz 25.5-27.0 GHz 37-38 GHz	S X Ka Ka	8450-8500 MHz	2200 – 2290 MHz 8450 – 8500 MHz 25.5 – 27.0 GHz
Earth to Lunar Surface	2025-2110 MHz 7190-7235 MHz 22.55-23.15 GHz	S C K	7190-7235 MHz	2025 – 2110 MHz 7190 – 7235 MHz 22.55 – 23.15 GHz
Lunar Surface to Earth	2200-2290 MHz 8450-8500 MHz 25.5-27.0 GHz	S X Ka	8450-8500 MHz	2200 – 2290 MHz 8450 – 8500 MHz 25.5 – 27.0 GHz
Lunar Orbit to Lunar Surface	390-405 MHz 2025-2110 MHz 23.15-23.55 GHz	UHF S K	390-406.1 MHz	406 – 406.1 MHz (emergency beacon) 2025 – 2110 MHz 23.15 – 23.55 GHz
Lunar Surface to Lunar Orbit	435-450 MHz 2200-2290 MHz 27.0-27.5 GHz	UHF S Ka	440-450 MHz	435 – 450 MHz 2200 – 2290 MHz 27.0 – 27.5 GHz
Lunar Orbit to Lunar Orbit	2025-2110 MHz 2200-2290 MHz 23.15-23.55 GHz 27.0-27.5 GHz	S S K Ka		2025 – 2110 MHz 2200 – 2290 MHz 23.15 – 23.55 GHz 27.0 – 27.5 GHz
Lunar Surface Wireless Network	390-405 MHz 410-420 MHz 435-450 MHz 2.400-2.480 GHz 2.5035-2.655 GHz 3.5-3.8 GHz 5.15-5.835 GHz 5.855-5.925 GHz 25.25-25.5 GHz 27.225-27.5 GHz 27.5-28.35 GHz	UHF UHF UHF S S S C C Ka Ka Ka	390-406.1 MHz 420-430 MHz 440-450 MHz 2 400-2 690 MHz 2 400-2 690 MHz 3 500-3 800 MHz 5 150-5 570 MHz 5 775-5 925 MHz 25.25-28.35 GHz 25.25-28.35 GHz 25.25-28.35 GHz	406 – 406.1 MHz (emergency beacon) 410 – 420 MHz 435 – 450 MHz 2.4 – 2.48 GHz 2.503 – 2.655 GHz 3.5 – 3.8 GHz 5.15 – 5.835 GHz 5.855 – 5.925 GHz 25.25 – 25.50 GHz 27.225 – 27.5 GHz 27.5 – 28.35 GHz
Lunar Relay to Lunar Relay Cross Link	13.75-14 GHz 14.5-15.35 GHz 23.15-23.55 GHz 27.0-27.5 GHz 37-38 GHz 40-40.5 GHz	Ku Ku K Ka Ka Ka		13.75 – 14.0 GHz 14.5 – 15.35 GHz 23.15 – 23.55 GHz 27.0 – 27.5 GHz
Amateur Radio Operations, Earth-to-Lunar Orbit	144-146 MHz 435-438 MHz 2.4-2.45 GHz 5.65-5.67 GHz	VHF UHF S C		
Amateur Radio Operations, Lunar Orbit-to-Earth	144-146 MHz 435-438 MHz 10.45-10.5 GHz	VHF UHF X		
Lunar PNT (LunaNet AFS for Navigation)	2483.5-2500 MHz	S		2483.5 – 2500 MHz
Earth GNSS to Lunar Surface		L L L		1164 – 1215 MHz 1215 – 1300 MHz 1559 – 1610 MHz
Optical Links				Optical: 1550 nm (Proximity Link) Optical: 1550 nm (Cross Link) Optical: 1550 nm (Trunk Link)

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## Notes

### LunaNet and Lunar Communications:

- 1) Lunar Spectrum Overview and World Radio Conference Update, NASA 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_02\\_01.pdf?utm\\_source=chatgpt.com](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_02_01.pdf?utm_source=chatgpt.com)
- 2) International Spectrum Regulatory Recognition of Lunar and Cislunar Activities, NASA, <https://arc.aiaa.org/doi/10.2514/6.2024-4856>
- 3) PNT as an Enabling Capability for Artemis, NASA, 2025, <https://www.ioag.org/Cislunar%20PNT%20Workshop/03%20PNT%20as%20an%20Enabling%20Capability%20for%20Artemis.pdf>
- 4) LunaNet Overview and Interoperability for Lunar PNT, NASA, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Framework%20%26%20Systems%20\(Part%20I\)/01%20LunaNet%20for%20ICG-IOAG%20CisLun%20PNT%2011-13Feb2025v4.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Framework%20%26%20Systems%20(Part%20I)/01%20LunaNet%20for%20ICG-IOAG%20CisLun%20PNT%2011-13Feb2025v4.pdf)
- 5) Overview of LCRNS PNT Services, NASA, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Framework%20%26%20Systems%20\(Part%20I\)/03%20PNT%20Workshop%20LCRNS%20PNT%20Services\\_v6.pdf?d=w98d1a0836ebb4705a0552ecdd443fda1](https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Framework%20%26%20Systems%20(Part%20I)/03%20PNT%20Workshop%20LCRNS%20PNT%20Services_v6.pdf?d=w98d1a0836ebb4705a0552ecdd443fda1)
- 6) LunaNet AFS Properties and Signal Band, NASA, ESA, JAXA, 2025, <https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/03%20LunaNet%20AFS%20Properties%20for%20ICG-IOAG.pdf>
- 7) LunaNet Perspectives - How the International Standards Community Can Help, NASA, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3\(2a\).%20Time%20%26%20Reference%20Systems%20Application/05%20LunaNet-InternlStdsHelpICG-IOAGPNTFeb2025v4.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3(2a).%20Time%20%26%20Reference%20Systems%20Application/05%20LunaNet-InternlStdsHelpICG-IOAGPNTFeb2025v4.pdf)
- 8) The Road Ahead: From Cislunar PNT to the Solar System Internet, Scott Pace, 2025, <https://www.ioag.org/Cislunar%20PNT%20Workshop/5.%20Lunar%20PNT%20Governance/02%20Cislunar%20PNT%20to%20SSI%20Feb%202025%20-%20Pace%20FinalR1.pdf>
- 9) Lunar Communications and Navigation: Integrating Government, Commercial, and International Partner Solutions, NASA, 2023, <https://ntrs.nasa.gov/api/citations/20230013706/downloads/GFFS%20-%20Cislunar%20Infrastructure%20-%20Reinhart%20-%20final.pdf>
- 10) Lunar Spectrum Considerations, ICG-17 Plenary, NASA, Cathy Sham, 2023, <https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17.02.08.pdf>
- 11) Interoperability Management on the Lunar Surface, NASA, 2024, <https://ntrs.nasa.gov/api/citations/20240010829/downloads/Interoperability%20Lecture%208%2029%2024.pdf>
- 12) NASA's Lunar Communication and Navigation Architecture, NASA, 2023, <https://ntrs.nasa.gov/api/citations/20230016359/downloads/Lunar%20Communications%20and%20Navigation%20Architecture.pdf>
- 13) Resolution 680 (WRC-23) Studies on frequency-related matters, including possible new or modified space research service (space-to-space) allocations, for future development of communications on the lunar surface and between lunar orbit and the lunar surface, ITU, [https://www.itu.int/dms\\_pub/itu-r/oth/0c/0a/ROCOA0000100015PDFE.pdf](https://www.itu.int/dms_pub/itu-r/oth/0c/0a/ROCOA0000100015PDFE.pdf)
- 14) LunaNet Governance: Organizing and Planning for LunaNet Operations, NASA, <https://dataverse.jpl.nasa.gov/dataset.xhtml?persistentId=doi:10.48577/jpl.O4ULBE>
- 15) International Coordination and Cooperation On LunaNet Spectrum Deck, NASA, 2024, <https://ntrs.nasa.gov/api/citations/20240011969/downloads/International%20Coordination%20on%20LunaNet%20Spectrum.pdf>
- 16) International Coordination and Cooperation on LunaNet Spectrum Report, NASA, 2024, [https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024\\_Ka-Band\\_LunaNet\\_Spectrum.pdf](https://ntrs.nasa.gov/api/citations/20240011047/downloads/2024_Ka-Band_LunaNet_Spectrum.pdf)
- 17) LunaNet: A Flexible and Extensible Lunar Exploration Communications and Navigation Infrastructure, NASA, <https://ntrs.nasa.gov/api/citations/20200001555/downloads/20200001555.pdf>
- 18) LunaNet Perspective, 2025, JAXA, [https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3\(2a\).%20Time%20%26%20Reference%20Systems%20Application/03%20LunaNet%20Perspectives,%20Frame,%20Suzuna%20OKAMOTO%20\(JAXA\)\\_A.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3(2a).%20Time%20%26%20Reference%20Systems%20Application/03%20LunaNet%20Perspectives,%20Frame,%20Suzuna%20OKAMOTO%20(JAXA)_A.pdf)
- 19) Deeper Dive into Interoperability and its Implications for LunaNet Communication and Navigation Services, NASA, <https://ntrs.nasa.gov/api/citations/20240007403/downloads/Interoperability%20for%20LunaNet%20Services.pdf>
- 20) A Deeper Dive in to the Meaning and Implications of Interoperability for LunaNet Communications and Navigation Services, NASA, 2023,

- [https://ntrs.nasa.gov/api/citations/20230013343/downloads/K\\_A\\_2023%20-%20Interoperability%20for%20LunaNet.pdf](https://ntrs.nasa.gov/api/citations/20230013343/downloads/K_A_2023%20-%20Interoperability%20for%20LunaNet.pdf)
- 21) A Deeper Dive in to the Meaning and Implications of Interoperability for LunaNet Communications and Navigation Services Report, NASA, 2023, [https://ntrs.nasa.gov/api/citations/20230013183/downloads/K\\_A\\_2023-Meaning%20of%20Interoperability%20for%20LunaNet.pdf](https://ntrs.nasa.gov/api/citations/20230013183/downloads/K_A_2023-Meaning%20of%20Interoperability%20for%20LunaNet.pdf)
  - 22) NASA's LunaNet Lunar Communications and PNT, NASA, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_02.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_02.pdf)
  - 23) LunaNet: Interoperability for Lunar PNT, NASA 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_01.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_01.pdf)
  - 24) Space Communications in Support of the Artemis Program, NASA, 2021, [https://ntrs.nasa.gov/api/citations/20210014268/downloads/SpaceOps%202021%20-%20Space%20Communications%20in%20Support%20of%20the%20Artemis%20Program\\_v3.pdf](https://ntrs.nasa.gov/api/citations/20210014268/downloads/SpaceOps%202021%20-%20Space%20Communications%20in%20Support%20of%20the%20Artemis%20Program_v3.pdf)
  - 25) LunaNet: Empowering Artemis with Communications and Navigation Interoperability, NASA, <https://www.nasa.gov/humans-in-space/lunanet-empowering-artemis-with-communications-and-navigation-interoperability/>
  - 26) Interoperability in the Lunar Sphere through LunaNet and International Cooperation, NASA, 2024, <https://ntrs.nasa.gov/api/citations/20240007199/downloads/LunaNet%20and%20Interoperability%20for%20Interop%20Tokyo%20v2.pdf>
  - 27) LunaNet Governance: Organizing and Planning for LunaNet Operations, NASA, 2023, <https://ntrs.nasa.gov/api/citations/20220010521/downloads/SpaceOps%202023%20Abstract%20on%20LunaNet%20Governance.pdf>
  - 28) LunaNet PNT Services, Enabling the Future of Lunar Exploration, NASA, 2023, <https://ntrs.nasa.gov/citations/20230013211>
  - 29) Lunar Foundational Reference Systems and Time: LunaNet Perspective, NASA, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_02\\_02.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_02_02.pdf)
  - 30) U.S. Policy on Celestial Time Standardization, NASA, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_02\\_03.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_02_03.pdf)
  - 31) LunaNet Interoperability Specification Document, NASA, <https://www.nasa.gov/wp-content/uploads/2023/09/lunanet-interoperability-specification-v5-draft.pdf>
  - 32) NASA's Efforts to Pursue Commercial Communication Services for Missions in Near Space Report, NASA, [https://ntrs.nasa.gov/api/citations/20230013271/downloads/Ka-band%202023\\_%20NASA%20CSP%20in%20Near%20Space.pdf](https://ntrs.nasa.gov/api/citations/20230013271/downloads/Ka-band%202023_%20NASA%20CSP%20in%20Near%20Space.pdf)
  - 33) NASA's Efforts to Pursue Commercial Communication Services for Missions in Near Space Deck, NASA, [https://ntrs.nasa.gov/api/citations/20230013314/downloads/Commerical%20Lunar%20Ka%20Presentation\\_FLNAL.pdf](https://ntrs.nasa.gov/api/citations/20230013314/downloads/Commerical%20Lunar%20Ka%20Presentation_FLNAL.pdf)
  - 34) 3GPP Mobile Telecommunications Technology on the Moon, NASA, 2023, <https://ntrs.nasa.gov/api/citations/20230002379/downloads/Big%20Sky%20Presentation.2.20.23.pdf>
  - 35) Nokia Future Lunar Surface Network Study, 2024, <https://ntrs.nasa.gov/api/citations/20240003815/downloads/NASA%203GPP%20Study%20Final%20Project%20Report%20Consol%20UDR.pdf>
  - 36) Lunar Communications Architecture: Enabling the Next Era of Space Exploration, New Space Economy, <https://newspaceeconomy.ca/2024/09/02/lunar-communications-architecture-enabling-the-next-era-of-space-exploration/?amp=1>
  - 37) NASA's Approach to Lunar Communications and Navigation: Artemis and Beyond, NASA, 2024, [https://ntrs.nasa.gov/api/citations/20240012244/downloads/IAC%202024%20NASA%20SCaN%20Lunar%20Architecture\\_FINAL.pdf](https://ntrs.nasa.gov/api/citations/20240012244/downloads/IAC%202024%20NASA%20SCaN%20Lunar%20Architecture_FINAL.pdf)
  - 38) Gateway - A Communications Platform for Lunar Exploration, NASA, 2021, [https://ntrs.nasa.gov/api/citations/20210018935/downloads/GW\\_Comm\\_ICSSC\\_Paper.pdf](https://ntrs.nasa.gov/api/citations/20210018935/downloads/GW_Comm_ICSSC_Paper.pdf)
  - 39) Lunar Reference Frame Update to the PAC, 2024, NASA, <https://science.nasa.gov/wp-content/uploads/2024/08/22-lunar-reference-frame-update-pac-july2024.pdf>
  - 40) LCRNS Version 4, NASA, <https://tempo.gsfc.nasa.gov/static-files/LunaNet%20Interoperability%20Specification.pdf>
  - 41) CesiumAstro Development of LunaNet AFS Receiver, Cesium, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/6\\_%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/03%20CesiumAstro%20Lunar%20AFS%20Final.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6_%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/03%20CesiumAstro%20Lunar%20AFS%20Final.pdf)
  - 42) From NaviMoon to NaviLunar - SpacePNT Roadmap from Autonomous Cis-Lunar Navigation to LunaNet Enabled Applications, SpacePNT, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/6\\_%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/04%20ICG-IOAG\\_Cislunar\\_PNT.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6_%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/04%20ICG-IOAG_Cislunar_PNT.pdf)

- 43) GNSS and LCNS Receiver technologies from the Lab to the Moon, Qascom, 2025,  
[https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/05%20ICGIOAG%20Workshop%20on%20Cislunar%20PNT%20Fantinato\\_v14.pdf?d=wdf46c025eded4fe6a260973421dddb9e](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/05%20ICGIOAG%20Workshop%20on%20Cislunar%20PNT%20Fantinato_v14.pdf?d=wdf46c025eded4fe6a260973421dddb9e)
- 44) Intuitive Machines LANS/PNT Lunar User Terminal Architecture, Intuitive Machines, 2025,  
[https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/06\\_Stewart\\_ICG\\_IOAG\\_IM\\_AF\\_S\\_RX\\_Vienna\\_Feb2025.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/06_Stewart_ICG_IOAG_IM_AF_S_RX_Vienna_Feb2025.pdf)

#### Lunar Spectrum Management Portal:

- 1) LSMP Homepage,  
<https://www.nasalsmp.org/SitePages/About-the-Lunar-Spectrum-Manager.aspx>
- 2) Recommended Frequency Bands,  
<https://www.nasalsmp.org/SitePages/Recommended-Frequency-Bands.aspx>
- 3) Lunar Mission Landscape,  
<https://www.nasalsmp.org/SitePages/Lunar-Mission-Landscape.aspx>
- 4) Spectrum Regulations for Lunar Environment System,  
<https://www.nasalsmp.org/SitePages/Spectrum-Regulations-for-Lunar-Region-Systems.aspx>
- 5) NASA Spectrum Planning & Pre-Coordination: Lunar Missions, Catherine Sham, Youtube,  
[https://www.youtube.com/watch?v=bk7eic\\_tlnA](https://www.youtube.com/watch?v=bk7eic_tlnA)

#### China Lunar Plans:

- 1) Strategic PNT Requirements for ILRS: Enabling Sustainable Lunar Exploration, 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/0.%20Keynote%20Addresses/02%20Preliminary%20PNT%20requirements%20for%20ILRS.pdf>
- 2) Conception of Lunar PNT, 2025, DSEL,  
[https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20\(Part%20II\)/02%20Conception%20of%20Lunar%20PNT.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20(Part%20II)/02%20Conception%20of%20Lunar%20PNT.pdf)
- 3) Spectrum Conception on Navigation Satellite of CAST: From the Earth to the Moon (CAST), 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/05%20ICG-IOAG-Huiliang%20LIU-Spectrum%20Conception%20on%20Navigation%20Satellite.pdf>
- 4) Evolution and Integration of BDS: Experiences Sharing with the Moon, 2025, CAST,

- [https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/05%20ICGIOAG%20Workshop%20on%20Cislunar%20PNT%20Fantinato\\_v14.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/05%20ICGIOAG%20Workshop%20on%20Cislunar%20PNT%20Fantinato_v14.pdf)
- 5) Necessity of Governance, 2025, IOAG and CNSA,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/5.%20Lunar%20PNT%20Governance/00%20Governance%20Session%20-%20Introduction--cochairs.pdf>
- 6) Considerations on Lunar PNT Governance, CNSA LESEC, 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/5.%20Lunar%20PNT%20Governance/03%20Considerations%20on%20Lunar%20PNT%20Governance%20Principles-Ruihong%20YANG.pdf>
- 7) The Envision of Earth-Moon and Deep Space Communication-Navigation-Remote Sensing Integrated Constellation System 2024,  
[https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_06.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_06.pdf)
- 8) The Envision of Earth-Moon and Deep Space Communication-Navigation-Remote Sensing Integrated Constellation System 2023,  
[https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17\\_wgb\\_06.pdf](https://www.unoosa.org/documents/pdf/icg/2023/ICG-17/icg17_wgb_06.pdf)
- 9) Research on Lunar Communication Network Architecture and Protocol, 2023,  
<https://ieeexplore.ieee.org/document/10367385>
- 10) International Research Station (ILRS), CNSA, 2023,  
[https://www.unoosa.org/documents/pdf/copuos/2023/TPs/ILRS\\_presentation20230529\\_.pdf](https://www.unoosa.org/documents/pdf/copuos/2023/TPs/ILRS_presentation20230529_.pdf)
- 11) Verification of BDS SSV and Analysis of BDS/GNSS Applications in Lunar Vicinity, June 2024,  
[https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_07.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_07.pdf)

#### Non-U.S. Lunar PNT Plans:

- 1) NovaMoon: A LANS Monitoring and Local Differential Station, ESA, 2025,  
[https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/07%20NOVAMOON\\_A%20LANS%20Monitoring%20and%20Local%20Differential%20Station\\_Dr%20Javier%20Ventura-Traveset.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/07%20NOVAMOON_A%20LANS%20Monitoring%20and%20Local%20Differential%20Station_Dr%20Javier%20Ventura-Traveset.pdf)
- 2) ESA Lunar Navigation Strategy: Moonlight, Lunar Pathfinder and NovaMoon Programmes, 2025,  
[https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20\(Part%20I\)/02%20ESA%20Lunar%20PNT%20Strategy\\_Dr%20Javier%20Ventura-Traveset\\_ESA.pdf?d=waf74d10c6571437394a4df9d8567201c](https://www.ioag.org/Cislunar%20PNT%20Workshop/1a.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20(Part%20I)/02%20ESA%20Lunar%20PNT%20Strategy_Dr%20Javier%20Ventura-Traveset_ESA.pdf?d=waf74d10c6571437394a4df9d8567201c)
- 3) Outline of Lunar Exploration Scenario in ISECG, JAXA, 2025,



- <https://www.ioag.org/Cislunar%20PNT%20Workshop/0.%20Keynote%20Addresses/01%20Outline%20of%20Lunar%20Exploration%20Scenario%20in%20ISECG.pdf>
- 4) Japan Lunar Navigation Satellite System (LNSS) and Its Contribution Towards LANS, JAXA, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20\(Part%20II\)/01%20Japan%20Lunar%20Navigation%20Satellite%20System%20\(LNSS\)%20and%20Its%20Contribution%20Towards%20LANS\\_Masaya\\_Murata\\_public.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20(Part%20II)/01%20Japan%20Lunar%20Navigation%20Satellite%20System%20(LNSS)%20and%20Its%20Contribution%20Towards%20LANS_Masaya_Murata_public.pdf)
  - 5) Lunar Navigation Satellite System (LNSS) and Its Demonstration Mission, Arkedge Space - JAXA, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/08%20250213\\_CisLunar\\_WS\\_Presentation\\_AE.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/08%20250213_CisLunar_WS_Presentation_AE.pdf)
  - 6) Pseudolite System for Lunar PNT, ISRO, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20\(Part%20II\)/03%20Pseudolite%20System%20for%20Lunar%20PNT\\_Cislunar\\_Workshop\\_11\\_Feb2025\\_Ashish\\_ISRO\\_FINAL.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20(Part%20II)/03%20Pseudolite%20System%20for%20Lunar%20PNT_Cislunar_Workshop_11_Feb2025_Ashish_ISRO_FINAL.pdf)
  - 7) Korean Cislunar PNT, KARI, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20\(Part%20II\)/04%20250211\\_Cislunar%20Workshop\\_Korean%20Cislunar%20PNT\\_jm\\_joo.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/1b.%20Overview%20of%20Lunar%20PNT%20Frameworks%20%26%20Systems%20(Part%20II)/04%20250211_Cislunar%20Workshop_Korean%20Cislunar%20PNT_jm_joo.pdf)
  - 8) Pseudolite Lunar PNT Spectrum Perspective, ISRO, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/04%20Pseudolite\\_PNT\\_Spectrum\\_Perspective\\_Cislunar\\_Workshop\\_12\\_Feb2025\\_Ashish\\_ISRO\\_FINAL.pdf?d=w54c7544f7b7849d780d2182b8fc8c010](https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/04%20Pseudolite_PNT_Spectrum_Perspective_Cislunar_Workshop_12_Feb2025_Ashish_ISRO_FINAL.pdf?d=w54c7544f7b7849d780d2182b8fc8c010)
  - 9) BIPM Perspective, BIPM, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3\(1\).%20Time%20%26%20Reference%20Systems,%20Frames%20-%20Definition%20%26%20Standards/03%20Tavella%20ICG%20IOAG%20Moon%20PNT%20Vienna%20feb%202025.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/3.%20Lunar%20Reference%20Systems%20and%20Timing/3(1).%20Time%20%26%20Reference%20Systems,%20Frames%20-%20Definition%20%26%20Standards/03%20Tavella%20ICG%20IOAG%20Moon%20PNT%20Vienna%20feb%202025.pdf)
  - 10) Leveraging PNT Receivers in 2483.5 - 2500 MHz for Lunar In-Situ Users, CNES, 2025, [https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/01\\_CNES\\_Issler.pdf](https://www.ioag.org/Cislunar%20PNT%20Workshop/6.%20Lunar%20PNT%20User,%20Test%20Equipment%20%26%20Technologies/01_CNES_Issler.pdf)
  - 11) Joint WG Session on Lunar PNT June 2024, [https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/b/LunarPNT\\_Jun24.html](https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/b/LunarPNT_Jun24.html)
  - 12) Lunar Reference Frame and Lunar Time Reference - ESA's View, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_02\\_04.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_02_04.pdf)
  - 13) Japan Lunar Navigation Satellite System (LNSS) and its Contribution Towards Lunar Augmented Navigation Service, JAXA, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_05.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_05.pdf)
  - 14) Moonlight: LCNS, and Lunar Pathfinder, ESA, 2024, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_04.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_04.pdf)
  - 15) LuGRE Lunar GNSS Receiver Experiment Deck, NASA, [https://www.unoosa.org/documents/pdf/icg/2024/WG-B\\_Lunar\\_PNT\\_Jun24/LunarPNT\\_Jun24\\_01\\_03.pdf](https://www.unoosa.org/documents/pdf/icg/2024/WG-B_Lunar_PNT_Jun24/LunarPNT_Jun24_01_03.pdf)
  - 16) ArkEdge Space Selected by JAXA to Develop Lunar Navigation System, 2024, <https://news.satnews.com/2024/12/03/arkedge-space-selected-by-jaxa-to-develop-lunar-navigation-system/>
- IOAG:**
- 1) IOAG LunaNet Governance Study Preliminary Results, 2025, <https://www.ioag.org/Cislunar%20PNT%20Workshop/5.%20Lunar%20PNT%20Governance/04%20IOAG%20LunaNet%20Governance%20Study%20Preliminary%20Results%20final.pdf>
  - 2) Committee to Study LunaNet Governance Terms of Reference, IOAG, <https://www.ioag.org/Public%20Documents/Committee%20to%20Study%20LunaNet%20Governance%20TOR.pdf>
  - 3) Cislunar Infrastructure: Convergence of Architecture, Governance, and Interoperability, 2024, <https://ntrs.nasa.gov/api/citations/20240005560/downloads/Cislunar%20Infrastructure.pdf>
  - 4) Interoperability Plenary Communique June 2023, [https://www.ioag.org/Public%20Documents/IOP-5%20Communique\\_FINAL.pdf](https://www.ioag.org/Public%20Documents/IOP-5%20Communique_FINAL.pdf)
  - 5) Report from IOAG to ICG, 2023, <https://www.unoosa.org/documents/pdf/icg/2023/PF-27/PF-27.01b.pdf>
  - 6) The Future Lunar Communications Architecture, 2022, <https://www.ioag.org/Public%20Documents/Lunar%20communications%20architecture%20study%20report%20FINAL%20v1.3.pdf>
  - 7) Update on Frequency Bands for Lunar In-Situ PNT/GNSS Constellations, ICG, 2022, <https://www.unoosa.org/documents/pdf/icg/2022/ICG16/09.pdf>

- 8) Public IOAG Documents Database,  
<https://www.ioag.org/public%20Documents/Forms/AllItems.aspx#>

#### **CCSDS:**

- 1) How CCSDS can Contribute to Cislunar PNT Interoperability, 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/4.%20GNSS%20Lessons%20Learned/06%20CCSDS-LunarPNT-13-02-25.pdf>
- 2) CCSDS, <https://public.ccsds.org/default.aspx>
- 3) Blue Book of Recommended Standards,  
<https://public.ccsds.org/Pubs/883x0b2.pdf>
- 4) CCSDS LunaNet Developers Forum,  
<https://public.ccsds.org/meetings/2023Fall/DevForum.aspx>
- 5) CCSDS Lunar Interoperability Forum,  
<https://public.ccsds.org/LunarForum.aspx>
- 6) Spectrum Factors Considered by Lunar In-Situ PNT Service Design in the Lunar Environment, 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/02%20Spectrum%20Factors%20for%20Lunar%20PNT%20Service%20in%20the%20Lunar%20Environment.pdf>

#### **SFCG:**

- 1) SFCG Overview and WRC-27 Lunar Objective, 2025,  
<https://www.ioag.org/Cislunar%20PNT%20Workshop/2.%20Lunar%20PNT%20Spectrum/01%20IOAG-ICG%20on%20Lunar%20PNT-Feb2025-SFCG.pdf>
- 2) Frequency Assignment Guidelines for Communications in the Mars Region, Recommendation SFCG 22-1R4,  
<https://www.unoosa.org/documents/pdf/icg/2022/ICG16/09.pdf>
- 3) [SFCG REC 32-2R5](#): Recommends frequencies for lunar communications, PNT services, and search-and-rescue operations.
- 4) [SFCG RES 23-5](#): Limits active system use in the Moon's Shielded Zone to protect radio astronomy and requires coordination for such activities.
- 5) [SFCG REC 41-1](#): Establishes technical requirements for efficient spectrum use in Earth-to-space, space-to-space, and lunar relay communications.
- 6) [SFCG REC 42-1](#): Defines S-band and Ka-band frequency plans for in-situ lunar data relay to support interoperability and communication.
- 7) [SFCG REC 29-2](#): Provides guidelines for active remote sensing frequencies in the lunar region, ensuring compatibility with passive science missions like radio astronomy.
- 8) [SFCG Prov. REC 43-1](#): Recommends design considerations to protect in-situ S-band PNT links from

interference caused by lunar surface communications systems.

- 9) [SFCG RES A 40-1](#): Recommends space agencies and commercial entities coordinate with their respective national space agencies and consult the NASA-developed Lunar Spectrum Management Portal ([LSMP](#)) during the initial planning stages of lunar missions.

#### **FCC Lunar Applications:**

- 1) Lockheed Martin/Crescent Space Parsec, Primary:  
<https://fcc.report/IBFS/SAT-LOA-20220218-00020>  
Additional: <https://s3.amazonaws.com/warren-news.com/pdf/879521>
- 2) Lockheed Martin/Crescent Space 230 Lunar Stations,  
<https://fcc.report/IBFS/SAT-LOA-20230315-00060>  
Additional:  
[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=23036041](https://licensing.fcc.gov/myibfs/download.do?attachment_key=23036041)
- 3) Intuitive Machines, Nova-C/IM-1 Lunar Lander,  
<https://fcc.report/IBFS/SAT-LOA-20210423-00055>
- 4) Lockheed Martin Lunar WAC Comments, 2022,  
<https://www.fcc.gov/ecfs/search/search-filings/filing/1092629914809>
- 5) Blue Origin ISAM Comments,  
<https://www.fcc.gov/ecfs/search/search-filings/filing/1031125796955>
- 6) CTIA Comments Against Lockheed's 230 Lunar Stations,  
[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=22718429](https://licensing.fcc.gov/myibfs/download.do?attachment_key=22718429)
- 7) Astrolab Comments Against Lockheed's 230 Lunar Stations,  
[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=24232971](https://licensing.fcc.gov/myibfs/download.do?attachment_key=24232971)
- 8) T-Mobile Comments Against Lockheed's 230 Lunar Stations,  
[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=22932385](https://licensing.fcc.gov/myibfs/download.do?attachment_key=22932385)
- 9) KSAT Comments Supporting Lockheed's 230 Lunar Stations,  
[https://licensing.fcc.gov/myibfs/download.do?attachment\\_key=22919961](https://licensing.fcc.gov/myibfs/download.do?attachment_key=22919961)
- 10) Firefly Aerospace,  
<https://docs.fcc.gov/public/attachments/DA-25-65A1.pdf>
- 11) Intuitive Machines,  
<https://docs.fcc.gov/public/attachments/DA-25-152A1.pdf>

#### **Other:**

- 1) FCC Lunar Spectrum Proposal to the ITU, [https://docs.fcc.gov/public/attachments/DA-22-954A3\\_Rcd.pdf](https://docs.fcc.gov/public/attachments/DA-22-954A3_Rcd.pdf)
  - 2) Lunar Landing and Operations Policy Analysis, NASA, 2022, <https://www.nasa.gov/wp-content/uploads/2023/05/nasa-opts-lunar-landing-and-operations-policy-analysis-final-report-2.pdf>
  - 3) Spectrum Management, GAO, 2021, <https://www.gao.gov/assets/gao-21-474.pdf>
  - 4) Lunar Celestial Reference System, ADS, 2023, <https://ui.adsabs.harvard.edu/abs/2023DPS....5510408K/abstract>
  - 5) National Cislunar Space Strategy, White House, <https://www.whitehouse.gov/wp-content/uploads/2024/12/Cislunar-Implementation-Plan-Final.pdf>
  - 6) CesiumAstro Gets NASA Contract for LunaNet Technology, ProQuest, <https://www.proquest.com/docview/3092479951?OpenUrlRefId=info:xri/sid:summon&sourcetype=Wire%20Feeds>
  - 7) 2024 Reports and Recommendations, Beyond Earth Institute, [https://beyondearth.org/wp-content/uploads/2024/11/BE\\_2024-Reports-and-Recommendations\\_For\\_Download-1.pdf](https://beyondearth.org/wp-content/uploads/2024/11/BE_2024-Reports-and-Recommendations_For_Download-1.pdf)
  - 8) The Evolution of Lunar Communication - From the Beginning to the Present, International Journal of Satellite Communications and Networking, 2023, <https://onlinelibrary.wiley.com/doi/10.1002/sat.1507>
  - 9) Outcomes of WRC-23, 2024, [https://www.itu.int/en/ituNews/Documents/2024/2024-01/2024\\_ITUNewsMag01-en.pdf](https://www.itu.int/en/ituNews/Documents/2024/2024-01/2024_ITUNewsMag01-en.pdf)
  - 10) FCC Seeks Comment on Recommendation Approved by WAC, <https://docs.fcc.gov/public/attachments/DA-24-774A1.pdf>
  - 11) U.S. Frequency Allocations Chart, [https://www.ntia.doc.gov/files/ntia/publications/january\\_2016\\_spectrum\\_wall\\_chart.pdf](https://www.ntia.doc.gov/files/ntia/publications/january_2016_spectrum_wall_chart.pdf)
  - 12) CITELE Lunar Spectrum, <https://www.oas.org/citelevents/en/Documents/DocumentsFile/2784>
  - 13) ESA Moonlight, [https://www.esa.int/Applications/Connectivity\\_and\\_Secure\\_Communications/Moonlight](https://www.esa.int/Applications/Connectivity_and_Secure_Communications/Moonlight)
  - 14) US-ESA MOU Lunar Pathfinder, <https://www.state.gov/wp-content/uploads/2023/10/22-615-European-Space-Agency-Space-Lunar-Pathfinder-6.15.2022-TIMS-63201.pdf>
  - 15) US-ESA LunaNet, [https://www.nasa.gov/wp-content/uploads/2023/04/joint\\_con\\_ops\\_document\\_dec\\_14\\_2022\\_final\\_draft.pdf](https://www.nasa.gov/wp-content/uploads/2023/04/joint_con_ops_document_dec_14_2022_final_draft.pdf)
  - 16) FCC 47 CFR 25.164 Spectrum Warehousing, <https://www.ecfr.gov/current/title-47/chapter-1/subchapter-B/part-25/subpart-B/subject-group-ECFR3e61a02158c60ca/section-25.164>
  - 17) FCC CFR Title 47 Part 5, Experimental Licenses, <https://www.ecfr.gov/current/title-47/chapter-1/subchapter-A/part-5?ref=broadbandbreakfast.com>
- NASA Lunar Spectrum Procurement Contracts:**
- 1) Near Space Network Services Subcat 2.2 Geo to Cislunar Relay Services, <https://sam.gov/opp/11bd877cf8774cf395d9e4e0e1c4d12f/view>
  - 2) Utilizing Public-Private Partnerships to Advance Tipping Point Technology, <https://sam.gov/opp/f447a808ce2d46279eae8e97fdd9dda1/view>
  - 3) Lunar Terrain Vehicle Instruments, <https://nspires.nasaprs.com/external/solicitations/summary!init.do?sollid={564C34E1-AD06-31DB-6E0D-4CDB3B1B4B66}&path=open>
  - 4) Economic, Social, and Policy Analyses of Lunar Surface Sustainability, [https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=983541/solicitationId=%7B48D6B21B-0171-D79D-E111-BCDFCC02E0F0%7D/viewSolicitationDocument=1/F.21%20ESPOD\\_Lunar\\_corrected.pdf](https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=983541/solicitationId=%7B48D6B21B-0171-D79D-E111-BCDFCC02E0F0%7D/viewSolicitationDocument=1/F.21%20ESPOD_Lunar_corrected.pdf)
  - 5) Interoperability Deep Space Standards, <https://internationaldeepspacestandards.com/>
  - 6) AFPP to Advance Tipping Point technologies, <https://nspires.nasaprs.com/external/solicitations/summary!init.do?sollid=%7B9987D88F-0A12-5203-FC25-423773FAF134%7D&path=open>
  - 7) Near Space Network Services, <https://sam.gov/opp/b7eb6748bd1f421db9910dac63e02b7c/view>
  - 8) LTE Proximity Communications for Future Lunar Missions, <https://sam.gov/opp/f458f0b0f0264a47a5830dd4e04468ab/view>
  - 9) NSN Final RFP, <https://sam.gov/opp/68866e644d1a447a964fc0bade9adf45/view>
  - 10) Lunar Terrain Vehicle Services (LTVS), <https://sam.gov/opp/fe165108df794d609b69282ed8b8a279/view>
  - 11) Lunar Logistics and Mobility Studies, <https://sam.gov/opp/d27e0ea1d72c4edab11d5c8a66f40f91/view>



- 12) 2025 Request for White Papers: NASA SBIR Phase II,  
<https://sam.gov/opp/8e541568b2c94fdb0846cb0b26853da/view>
- 13) 2024 SBIR Phase I - Advancing Lunar Communication Infrastructure Using Flexible Software Defined Radio,  
<https://www.highergov.com/contract/80NSSC24PB266/>