Long Term Development of the Cislunar Ecosystem

Policy Considerations and Recommendations

This paper is a product of the Cislunar Economy Working Group (2023) of the Beyond Earth Institute Leadership Council. While the paper represents a consensus of Working Group discussions, the views and recommendations do not necessarily represent those of the members or their respective organizations.

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I Executive Summary

The Beyond Earth (BE) Institute Working Group on the Cislunar Economy has identified key barriers hindering the current development of Cislunar Space and the Moon. Chief among these obstacles is the reluctance of governments to invest in essential infrastructure critical for advancing manufacturing, settlement, and exploration activities. Successful establishment and growth of the Cislunar Economy demand a concerted international effort by governments to prioritize investment in this frontier.

The primary challenges to generating a reliable investment framework for the Cislunar Economy revolve around international cooperation, the delicate balance between collaboration and competition, and the necessity of engagement. The Cislunar Economy Working Group group proposes solutions centered on collaborative regulation, aligned with existing government policies and initiatives such as the Artemis Accords.

International Cooperation

The current regulatory landscape, characterized by individual national regulations and diverse interpretations of the Outer Space Treaty, poses significant complications. To overcome these challenges, a collaborative approach must be adopted, emphasizing shared goals and mutual benefit among participating nations. Rather than relying on rigid regulations, a collaborative mission should encourage growth through cooperative practices and guidelines.

Collaboration vs. Competition

Similar to dynamics on Earth, the Cislunar Economy is expected to involve a mix of collaboration and competition among nations and corporations. Striking a balance between fostering cooperation, such as joint missions and technology sharing, and protecting national interests and proprietary knowledge presents a political challenge. Establishing frameworks for the protection, transfer, and commercialization of intellectual property will be crucial to incentivize innovation while promoting collaboration and knowledge sharing.

Engagement

Given the complex and fragile nature of the cislunar environment, proactive engagement is essential to prevent conflicts and disruptions. Space situational awareness and ecosystem preservation are critical concerns that demand international cooperation and innovative solutions. To garner stakeholder buy-in, a flexible framework favoring best practices over strict regulation is imperative to address immediate economic challenges and regulatory constraints, thereby optimizing outcomes in the Cislunar Economy.

II Background

While the 1976 United Nations Outer Space Treaty[1] largely neglects mention of developing policies promoting the cultivation of the cislunar economy, steps like the 1988 Space Settlement Act,[2] and the Artemis Accords[3] have taken major leaps towards bringing cultivation of space settlement to the forefront of policy discussions. The Space Settlement Act broached the Cislunar Economy only broadly, while the Artemis Accords has emphasized a return to the Moon as an international priority. The 1979 Moon Treaty, remains a substantial roadblock in cislunar economic development.[4] While the United States is not a party, the Moon Treaty largely prohibits states from extracting resources or establishing bases to preserve the Moon as a province for all mankind. In turn, the United States created the Artemis Accords to gather like-minded countries interested in space-extraction.

Focusing on the strategic and economic priorities of the Cislunar region, the National Cislunar Science and Technology Policy Strategy released in November 2022 by the White House National Science and Technology Council highlighted how Cislunar space offers immense promise for advancing technology and exploration.[5] For example, Cislunar space makes traveling to Mars, economic growth in space, and testing new technologies all possible. Further, a sustainable approach can foster international cooperation to achieve these goals.

The National Science and Technology Council emphasized several main objectives in Cislunar space, with the most pertinent being long-term growth to facilitate furthering secondary goals. Long term research in this area would lead to a better understanding of space science as a whole as well as technological and sociological breakthroughs crucial for the future of space settlement. Building off of the Artemis Accords, the second objective is to increase international cooperation acting in the interests of all nations in any further development of the Cislunar Economy. This includes reducing competition amongst spacefaring nations desiring to operate in this region. Through increasing technological capabilities and international cooperation, the third objective aims to support space situational awareness. The fourth objective is to implement Cislunar communications in space to ensure the success of missions like those of Artemis, ensuring that the infrastructure deployed on those missions is sustainable and incorporates commercial development at each step.

We must create a more solidified policy plan on how to invest in this area of space that could benefit not just the United States, but all spacefaring nations as well as non-government entities seeking to expand human presence to the Cislunar region.

When considering future goals, however, it is crucial to understand potential pitfalls in future planning. Existing international collaborative frameworks like the Moon Treaty will need to be circumvented to ensure the United States and like-minded states have the ability to act on commercial interests in developing the cislunar economy. While the Moon Treaty and Artemis Accords are not exactly incompatible, as Australia is party to both, it is likely that the standardization and international collaboration will need to be centered outside of the existing legal framework. The Artemis Accords exists as a prime venue to facilitate both the international cooperation and standardization required to promote more investment. On the one hand, the potential of private industry entities to independently fund and develop infrastructure is promising. On the other hand, high-entry level costs and low initial profitability provide steep hurdles for private industry

1 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Preamble, Jan. 27, 1967, 18 UST. 2410, 610 U.N.T.S. 205 (entered into force Oct. 10, 1967), *hereinafter* Outer Space Treaty.
2 Space Settlement Act of 1988, P.L. 100 - 685.
3 *The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids*, NASA (Oct. 13, 2020).
4 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. Mar. 12, 1979, 34 U.N.T.S 68 (entered into force July 11, 1984), *hereinafter* Moon Treaty.
5 Cislunar Technology Strategy Interagency Working Group, *National Cislunar Science & Technology Strategy*, National Science & Technology Council (November 2022), available at https://www.whitehouse.gov/wp-content/uploads/2022/11/11-2022-NSTC-National-Cislunar-ST-Strategy.pdf.

that will likely need to be initially aided by greater government investment. Above all, when considering the development of the Cislunar Economy, it is crucial to remain practical considering current capabilities and future shifting priorities. The reality of the Cislunar and Lunar region requires a realistic perspective on the challenges of the environment. For example, landing on the Moon can lead to dust being kicked up that can block visibility and pose a threat to suits and fragile machinery due to its being composed of silica and metals that can cut like glass. Unique practices and guidelines will need to be established to ensure lunar dust does not interfere with interstellar research while also allowing appropriate launch and landing facilities.

Lastly, a significant roadblock to encouraging Cislunar development revolves around public understanding and knowledge of space. Many individuals do not have a complete understanding of the differences between commercial versus government space ventures and may be reluctant to support future efforts if they think government funding could be better deployed on earth - e.g., co-combating climate change. Greater emphasis will need to be given to encouraging public understanding on the benefits of space research and technology as well as the difference between private, non-federally funded initiatives and government led missions.

III Current Issues

Based on discussions and working groups amongst field experts and professionals in the private sector, the major challenges facing the current development of the Cislunar Economy centers on the hesitancy of government investment in crucial infrastructure essential to jumpstart manufacturing, settlement, and exploration of the Cislunar Space and the Moon.

International Cooperation

As there is limited regulatory power for any treaty or agreement, cooperation must be based in a sense of cooperative engagement and benefit. What form this cooperation takes depends on the agendas driving various nations and their specific interests and goals, with the US prioritizing unrestricted access to space as underscored by the Artemis Accords. When considering differing perspectives from nations like China, for example, there is a potential that independent regulation of private and government activities will remain with the launch nation, requiring each state to regulate and encourage space practices on their own.

To overcome the issue of diverse international perspectives, a collaborative mission must be established so that, rather than regulating activity with an invisible and unenforceable hand, encourages growth in practices along collaborative guidelines. In practice, this takes the shape of international regimes for sharing data and space situational awareness as well as ensuring spacecraft designs incorporate universal components to enable joint missions for emergencies and other cooperative efforts.

Collaboration vs. Competition

The Cislunar Economy will inevitably involve both collaboration and competition among nation states and corporations. Political challenges may arise in striking a balance between fostering cooperative efforts, such as joint missions and technology sharing, and protecting national interests and proprietary knowledge. Defining frameworks for the protection, transfer, and commercialization of intellectual property will be a political challenge, ensuring incentives for innovation while promoting knowledge sharing and collaboration.The Cislunar Economy relies heavily on interconnected networks, communication systems, and data exchanges Encouraging responsible behavior, transparency, and trust-building measures among nations and stakeholders will be a political challenge in fostering a cooperative and stable Cislunar Ecosystem. Furthermore, the control and protection of critical infrastructure, technological advancements, and space assets are priority political considerations as nations seek to safeguard their interests and maintain a competitive edge.

Engagement

Like the aforementioned potential issues with lunar dust, space situational awareness in the Cislunar Environment also provides another issue that will require international engagement to find a solution. Consensus is lacking in international law on the goals and future practices of the Lunar and Cislunar Environment. Continuous evolution of these practices is needed due to the dynamic nature of outer space activities. International engagement favoring flexibility in decision-making is crucial to foster growth and promote a common purpose. An adaptable framework favoring best practices rather than regulation is vital to address immediate economic challenges and regulatory constraints for optimal outcomes. Rather than attempt to strictly limit what states can do via restrictive regulations, creating a looser framework with standards of cooperation allows greater flexibility for development and innovation while maintaining a common goal of interoperability. To build up transparency and confidence building measures between states, it is crucial that lessons learned from other terrestrial

cooperative agreements like the Rush-Bagot Treaty[7] and Antarctic Treaty[6] apply to the Cislunar Environment.

Thus, rather than relying on restrictive, punitive measures that might be applied to punish non conforming states, relying on creating common norms and behaviors could be more conducive to engineering a collaborative framework. There is a whole body of research on whether international behavior relies more on norms or realism (i.e., threat of punishment whether from multilateral or other groups). Perhaps we can suggest that it would be beneficial to apply lessons learned from confidence building measures and other terrestrial cooperative agreements to the cislunar region. For example, Rush-Bagot Treaty, Antarctic Treaty, and others for disarming regions and regulating behavior.

IV Potential Solutions

Keeping these challenges in mind, to develop a solution we must construct a variety of policy solutions and actionable items to create the foundation for the Cislunar economy. Policy recommendations can include creating a space traffic management system in which debris can be tracked and eliminated for a sustainable future in the Cislunar region, best-practices frameworks to encourage collaboration, and increased initial government investment in essential infrastructure. Considering first within the US, the government can incentivize investing in Cislunar infrastructure by providing grants to solve the aforementioned problem of funding. There is a potential that large scale financing models may provide an alternative solution, as have proven lucrative with deep sea mining investments, yet the BE Working Group on the Cislunar Ecosystem argue the importance of initial Government investment to continue developing the market.

The most focal solution lies in creating a centralized regulator for on orbit and on moon specifically. A reliable framework established through collaborative transparency would make a more attractive investment opportunity to hopefully increase the potential pool of investors. While NASA will play a role, neither NASA nor the US government should be the sole regulators or ultimate bank roller as future expansion will rely on commercial growth. The cislunar economy is an expansive arena of policy and development interests. Thus, some type of centralized regulating body encouraging the standardization of easy development practices can create the infrastructure to support and encourage private entities.

Moreover, an international framework that is more specific than the current guidelines of the Outer Space Treaty and deals specifically with Cislunar space must be curated in order to even begin work on developing an economy using this region. As for specific investment requirements and a potential timeline, the BE Cislunar Economy working group was in consensus that these are long term goals and long term projects, thus establishing specific goals or timelines would likely only be superficial. The environment is likely to change drastically between now and when more specific policies are adopted, so rather than harm potential development and further investment through missed deadlines or drastically changing environments, it's crucial to keep potential solutions to broader guidelines to begin building a solid foundation for future development.

Conclusion V

A stronger government investment stance on Cislunar and lunar infrastructure can renew commercial interest, but relying solely on commercial development is unrealistic. The most focal solution lies in creating a centralized regulator for on orbit and on moon specifically. A phased investment plan with incremental milestones may be insightful to build a self-sustaining ecosystem. Milestones like landing pads, medical facilities, and communication systems serve as targets in this time-bound plan, aiming to shape a future aligned with our current aspirations. However, there are many specifics that will need to be researched further in future studies as the environment develops, including specific investments amounts, detailed timelines, and additional crucial infrastructure that is currently unforeseen. Developing the Cislunar Economy is a goal for the future, with work that can only be completed once foundational developments and plans have been built, but by establishing crucial guidelines and directing the government and private sectors to best practices, that future can become a reality.

Summary of Recommendations

The stance of international governments on Cislunar investment remains one of the primary obstacles to growth. A stronger government investment stance on Cislunar and lunar infrastructure can renew commercial interest, but relying solely on commercial development is unrealistic. Specifically, an international framework that is more specific than the current guidelines of the Outer Space Treaty and deals specifically with Cislunar space must be curated to even begin work on developing an economy using this region. Once further efforts at cooperation have been established, a phased investment plan with incremental milestones is crucial to build a self-sustaining ecosystem. Milestones like landing pads, medical facilities, and communication systems serve as targets in this time-bound plan, aiming to shape a future aligned with our current aspirations.

Key areas highlighted by members of the BE Working

6 Rush-Bagot Treaty, 81 Stat. 1100.
7 Antarctic Treaty, 402 UNTS 71.

Group on the Cislunar Economy, field professionals include:

Lunar Landing Pads and Spaceports

- Construction of safe and reliable landing pads on the Moon and other celestial bodies within the cislunar region. Emphasizing debris and dust mitigation.
- Development of spaceports to support spacecraft landings, launch activities, and logistics operations.

Research and Development Facilities

- Establishment of advanced research and development facilities in the cislunar region, equipped with cutting-edge equipment and laboratories.
- Provision of specialized facilities for materials science, robotics, space medicine, and other relevant fields.

In-Situ Resource Extraction and Processing Infrastructure

- Development of mining operations and processing facilities to extract and process local resources available on the Moon and other celestial bodies.
- Implementation of efficient and sustainable technologies for resource utilization, including extraction, refining, and storage.

Space Manufacturing and Construction Capabilities

- Creation of in-space manufacturing capabilities, such as 3D printing and additive manufacturing, to produce structures, habitats, and components.
- Construction of facilities and equipment for manufacturing and assembling in the cislunar region, reducing dependency on Earth for supplies.

Advanced Communication Networks

- Deployment of robust and high-speed communication networks, including satellite constellations, ground stations, and relay systems.
- Development of secure and reliable communication infrastructure to facilitate data transfer, remote operations, and real-time collaboration.

Intra-Cislunar Transportation Systems

- Development of efficient and reusable transportation systems within the cislunar region, including spacecraft, lunar shuttles, and landing vehicles.
- Construction of docking and refueling stations to enable frequent and reliable transportation of crew, equipment, and resources.

Power Generation and Energy Infrastructure

- Establishment of sustainable power generation systems, such as solar arrays or nuclear reactors, to meet energy demands in the cislunar region.
- Implementation of energy distribution networks and storage solutions to ensure a reliable and continuous power supply.

Environmental Management and Waste Infrastructure

- Design and implementation of waste management systems to handle and mitigate waste generated by human activities in the cislunar region.
- Development of recycling and reusability programs to promote sustainable resource utilization and minimize environmental impact.

Habitats and Life Support Systems

- Construction of habitable structures and habitats to support long-duration missions and human presence in the cislunar region.
- Integration of life support systems, including air recycling, water purification, and food production, to sustain human life in space.

Navigation and Positioning Infrastructure

- Establishment of precise navigation and positioning systems to enable accurate spacecraft navigation, landing, and rendezvous operations.
- Deployment of satellite-based positioning systems and ground-based tracking facilities for reliable spacecraft tracking and monitoring.

This Report was drafted as part of the 2023 Cislunar Economy Working Group Meetings.

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