A Path Forward for Commercial Space Stations

Policy and Regulatory Considerations

This paper is a product of the Commercial Space Stations Working Group 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 individual members or their respective organizations.

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Executive Summary

Space exploration is rapidly transitioning from being primarily Government-led to a more commercially driven endeavor, aimed at affordable space settlement. As the International Space Station (ISS) approaches decommissioning, public-private partnerships are crucial to ensure continuous space laboratory capabilities. However, as the commercial space sector matures, the government's role must evolve from heavy oversight to one that supports market-driven growth, balancing public and private interests. Further, the shift from government-led space stations to privately operated ones poses regulatory challenges that require ongoing Government support and adaptation. The 2024 Commercial Space Stations Working Group has found that the success of commercial space stations hinges on contracting flexibility and regulatory clarity.

I. Background/Context

As the fabric of space activity has evolved and expanded, space exploration is expanding beyond the limits of the government. We've entered the commercial space age that is driving to realize a vision of affordable space settlement as the end goal.[1] The implications of this ongoing shift toward commercialization have been and will continue to be profound for business, policy, and society sectors.

This year alone, private companies have made significant strides in space exploration. SpaceX has successfully deployed 67 missions by mid-2024 and is aiming for 135 launches by the end of the year.[2] Among their notable achievements was the fifth test flight of SpaceX Starship, which completed a successful "catch" of the Super Heavy booster, marking a significant milestone in enabling space commercialization and exploration.[3] Intuitive Machines built the lunar lander Nova-C, designed to deliver small commercial payloads, including experiments and equipment, to the crater Malapert A near the moon's south pole.[4] The IM-1 mission, which launched on February 29th, 2024, had a multi-day window that began in mid-February and concluded seven days after landing.

Private astronaut missions have experienced significant growth this year as well. The Polaris Program is pushing forward with the Polaris Dawn mission, the first of three planned missions led by Jared Isaacman in partnership with SpaceX. In September, Polaris Dawn launched aboard a SpaceX Crew Dragon spacecraft atop a Falcon 9 rocket, making history with the first commercial spacewalk.[5] The mission marks another key achievement in private spaceflight, pushing the boundaries of what non-government space missions can achieve. To date, Axiom Space has flown three private astronaut missions to the ISS, with a fourth scheduled for early 2025.[6] Blue Origin also experienced a successful flight for the New Shepard Program in August, with the NS-26 flight.[7]

To ensure there is no gap in human and space laboratory capabilities, a seamless transition must be made from the International Space Station (ISS) to future Commercial Space Stations. However, strictly relying on the government's ability alone to support the type of expansive growth in space facility use is untenable as it alone can not maintain the free world's leading role in the emerging space econosphere. Through public-private partnership models, government agencies are now helping to stimulate commercial endeavors by imparting the wisdom of decades of development experience into private companies which are willing and able to advance the space industry at a much faster rate. The public-private partnership model operates on a symbiotic relationship between both parties which allows the entities to share decision-making power.

In the nascent years of Commercial Space Stations, it is likely that Government participation and support as anchor tenant will be a necessary stimulant. As is often the case with new and emerging commercial markets, these markets need to be fostered and supported by the Government until maturation to the point of long-term sustainability.

[1] Matthew Weinzerl & Mehak Sarang, The Commercial Space Age Is Here, HARVARD BUS. REV. (Feb. 12, 2021), https://hbr.org/2021/02/the-commercial-space-age-is-here (last visited Oct. 17, 2024).

[2] Alejandro Alcantarilla Romera, SpaceX continues record-breaking year with Starship's full success and Falcon milestones, NSF (July 1, 2024), https://www.nasaspaceflight.com/2024/07/spacex (last visited Oct. 17, 2024).

[3] Jeff Foust, SpaceX launches fifth Starship, catches Super Heavy booster, SPACENEWS (Oct. 13, 2024), https://spacenews.com/spacex-launches-fifth-starship-catches-super-heavy-booster/ (last visited Oct. 22, 2024).

[4] IM-1 Mission, INTUITIVE MACHINES, https://www.intuitivemachines.com/im-1 (last visited Oct. 17, 2024).

[5] Justin Davenport, Polaris Dawn returns home after landmark commercial spaceflight, NSF (Sept. 14, 2024) https://www.nasaspaceflight.com/2024/09/polaris-dawn-splashdown/ (last visited Oct. 17, 2024).

[6] Jeff Foust, Companies seek more opportunities to send private astronaut missions to ISS, SPACENEWS (Oct. 2, 2024), https://spacenews.com/companies-seek-more-opportunities-to-send-private-astronaut-missions-to-iss/ (last visited Oct. 17, 2024).

[7] Blue Origin Completes 26th Mission to Space with Six Crew Onboard, BLUE ORIGIN (Aug. 29, 2024), https://www.blueorigin.com/news/new-shepard-ns-26-mission (last visited Oct. 17, 2024).

A. Commercial Space Stations: Filling the ISS Void

The impending decommissioning of the ISS within the next decade presents both challenges and opportunities for growth of the commercial space sector.[8] The ISS has historically been unparalleled in providing an incubator for premium space technology and knowledge. It has operated for almost three decades as a large orbiting microgravity experimentation and technology laboratory, serving as a hub for astronauts and cosmonauts, all while doubling as a commercial test bed as well.

The decommissioning of the ISS has the National Aeronautic and Space Administration (NASA) currently working through a public private partnership model to avoid any capability gap. In February of 2020, NASA made an agreement with Axiom Space to develop an orbital segment that initially would be attached to the ISS and ultimately would operate as part of a fully commercial space station.[9] The next year NASA additionally entered into agreements with a variety of space companies including Blue Origin and Nanoracks LLC to build independent (non-government affiliated) space stations. Then, in January 2022 NASA issued the ISS space station transition report outlining the plan to support commercial growth in LEO via Commercial Low Earth Orbit (LEO) Destinations (CLDs) by 2030 to help fill the void left by the planned decommissioning of the ISS. Within the report, NASA stated their commitment to fully transitioning to commercially-operated space stations.[10] However, how and on what timetable that NASA plans to scale back Government oversight remains to be determined.

In addition to NASA's CLD partner organizations, other private space companies have also committed to create and deploy commercial first space habitats.[11] Vast's Haven-1 singular module space station is planned to launch by 2025.[12] Similarly, Starlab, a joint venture between Voyager Space, Airbus, Mitsubishi, MDA Space, Palantir Space, Hilton, Northrop Grumman, and Ohio State University has plans for a 2028 launch of a commercial space station that offers the "first science park in space."[13]

B. 2023 Working Group Findings

At the conclusion of the 2023 Leadership Council Working Group on Commercial Space Stations, the Working Group members identified two central challenges to the prospect of successful implementation of commercial space stations.[14] Amidst a lack of clear direction from the Administration and Congress, the future of commercial space habitats faces significant challenges, including regulatory obstacles in that there is a lack of ability to effectively mitigate liability exposure exacerbated by the absence of readily available commercial insurance.

In response to these concerns, the 2023 Working Group offered five key recommendations. First, it advocated for centralizing the regulation of on-orbit activities under a single governing body. Second, it suggested that the Department of Commerce is well-suited to serve as the coordinating regulator. Third, it recommended using the U.S. State Department's Circular 175 model for coordination across the Federal government. Fourth, it proposed a milestone-based approach to enforcement. Lastly, due to the difficulty of obtaining insurance for space activities, it expressed that the U.S. government should support the insurance industry by offering expertise and providing third-party indemnification coverage to the private sector.

II. Challenge: What Does It Mean to Be A Commercial Space Station?

With the private sector entering the domain of habitable space stations and other novel space activities, the government has recognized the pressing need for a regulatory scheme which supports growth. In conceptualizing the regulation and functionality of a fully commercial space venture like a CLD, the lingering question is: What does it actually mean to function as a CLD?

[8] FAQs: The International Space Station Transition Plan, NASA, https://www.nasa.gov/faqs-the-international-space-station-transition-plan/ (last visited Oct. 17, 2024).

[9] NASA Selects First Commercial Destination Module for International Space Station, NASA (Jan. 27, 2020), https://www.nasa.gov/press-release/nasaselects-first-commercial-destination-module-for-international- (last visited Oct. 17, 2024); Axiom Station, AXIOM SPACE, https://www.axiomspace.com/axiom-station (last visited Oct. 17, 2024).

[10] International Space Station Transition Report, NASA, 1,3 (January 2022).

[11] Commercial Destinations in Low Earth Orbit, NASA, https://www.nasa.gov/humans-in-space/commercial-space/low-earth-orbit-economy/commercial-destinations-in-low-earth-orbit/ (last visited Oct. 17, 2024).

[12] Roadmap, VAST SPACE, https://www.vastspace.com/roadmap (last visited Oct. 17, 2024).

[13] Starlab Space, STARLAB SPACE, https://starlab-space.com/ (last visited Oct. 17, 2024).

[14] Lauren Andrade, A Framework For The Effective Implementation Of Commercial Space Stations: Policy Considerations and Recommendations, Beyond Earth Institute Working Group Report (2023), https://beyondearth.org/wp-content/uploads/2023/10/Lauren-Article.pdf.

A. Shifting Toward A Commercial Model

The shift toward the CLD model is one that has ongoing Government support, but is not without growing pains. It is clear from the passage of legislation including the 2015 Commercial Space Launch Competitiveness Act, also commonly referred to as the Spurring Private Aerospace Competitiveness and Entrepreneurship Act (SPACE Act), that US citizens are authorized to "engage in commercial exploration for and commercial recovery of space resources free from harmful interference."[15] The SPACE Act expands the framework outlined in the Commercial Space Launch Act of 1984 (CSLA) and supports the commercial sector through regulatory and liability protections.[16] Despite the ongoing support for commercial space enterprise, the shift toward a fully commercial space station highlights the need for clear Government support of commercial space business models.

i. Commercial Contracting

As its name suggests, the public-private partnership model allows for a symbiotic relationship between Government and commercial entities. Combining public sector support and oversight with private sector capital, efficiency, and ability it seeks to tap into innovation and ensure U.S. competitiveness in the space market. Indeed, this Beyond Earth working group sees public sector support of CLD as essential to its success.

The shift away from government-funded and operated space stations like the ISS results in the necessary reliance on commercial enterprises to provide needed capability and support. However, the Government has yet to demonstrate a clear willingness to support commercial contract terms. This creates and presents significant challenges for the private sector. The result of this commercial contract reluctance puts CLD operators in a bind. Moreover, the NASA view of what constitutes a commercial transaction is fundamentally different from a traditional commercial venture between two non-government entities. On one hand NASA is used to greater levels of oversight and control afforded to them under traditional government managed contracts. On the other hand they also seek to obtain the cost advantages of being one of many "customers" of commercially-owned and operated space stations.[17] Ultimately, if the Government wishes to benefit from the CLD effort, there needs to be a clear willingness to operate within a commercial market and business framework. This means letting commercial vendors know their customer needs but operating as they have in the past executing traditional government contracts. The commercial vendors must then decide if they want to make the investments to meet this customer's needs.

ii. Multi-Interest Considerations

One important aspect of the CLD model is that commercial providers are by and large free to enter into contractual arrangements with a myriad of parties. This will likely result in multi-interest facilities capable of hosting missions with both Government and non-Government parties. This gives rise to additional questions about CLD functioning and Government customer interaction. Addressing mixed-occupant/payload missions, the CLD Working Group identified several key scenarios that must be addressed.

These identified scenarios recommended for further consideration include situations where NASA is not the primary customer and Government interest may be secondary, raising the question: What happens when a multi-customer mission with NASA participation but another customer is a larger stakeholder? Further, how will CLD handle NASA-astronaut tended third party payloads? Additionally, where the CLD contains independent non-human tended payloads, the CLD Working Group identified the need to articulate the protections and rights of the human versus payload stakeholders.

The common theme present in each of these scenarios is that trust in the CLD provider is essential to its success. From development, to NASA qualification for facility use, to their ultimate ability to provide commercial customer services, a CLD cannot function without the shared trust of both public and private stakeholders in its efficacy.

III. Recommendation: Commercial Space Station providers should adopt a multi-contract approach to balance public and private needs.

For CLD to function, both public and private customers need to trust the provider's ability to provide needed services, and thus there is necessarily a need to balance both public and private concerns. This need for a mechanism that fosters customer confidence is essential and relies on ongoing Government support of CLD providers. To that end, the CLD Working Group recognizes the key role NASA plays in the development and growth of CLD. As an established and proven globally-trusted leader in space activity, NASA's contribution to the CLD model builds commercial operators' credibility with regulators, which is critical to mission authorization and licensing. Taking into account the necessity of balancing both public and private interests, the CLD Working Group recommends a more simplified multi-contract approach to the CLD model. In order to adequately attend to the unique needs of a CLD at development, during qualification, and when providing services, the CLD Working Group recommends the implementation of a minimum of three complementary services type contracts that support the entire life cycle of the CLD.

[15] US Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90.
[16] 51 U.S.C. 50901 - 50923.
[17] NASA, supra note 11.

A. A Multi-Contract Approach

To attract investment opportunities, commercial companies need to be able to demonstrate they will have customers that can provide a return on investment. Key questions arise regarding the Government's role in this process. This includes things such as whether the agency will guarantee a minimum purchase of services and if it can provide enough business to a sufficient number of operators to make commercial space station ventures viable. The multi-contract approach allows for the gradual lessening of Government involvement in the CLD framework, to ensure that Government concerns are addressed throughout the development and qualification of the CLDs. Moving toward a lessening of Government involvement in the Services (operations) phase of the CLD.

B. Building Private Sector Trust

It is clear that the reliance on commercial space providers is by no means novel. In May 2009, President Barack Obama via the Office of Science and Technology Policy ("OSTP") created the Review of U.S. Human Spaceflight Plans Committee (or "Augustine Committee") to assess US involvement in the ISS, future missions outside of low Earth orbit, and the future of the commercial space industry.[18] The retirement of the space shuttle fleet placed reliance on America's ISS partners—in particular Russia but also the European Space Agency, and Japan—for station transport.[19] In response, NASA Administrator Charles Bolden stated that NASA "will foster a growing commercial space transportation industry that will allow NASA to focus our efforts on executing [the] direction in the act to start work on a heavy-lift architecture to take astronauts beyond low-Earth orbit, and to develop a multipurpose crew vehicle for use with our new space launch systems."[20]

i. What Does It Mean to Be Commercial? – The NASA Commercial Crew Model

Since 2020, NASA has relied on SpaceX to provide commercially operated transportation to and from the ISS through the Commercial Crew Program (CCP).[21] Prior to the implementation of the CCP, NASA funded and managed such programs, being fully involved in every detail of spacecraft development from initial design through construction and operation. By contrast, the CCP approach allows NASA to collaborate with the private sector to identify needs while allowing companies to design and construct spacecraft to their own specifications. Through this process, the private company maintains complete ownership and operational control of its spacecraft; however NASA imposes requirements during the development and qualification phases to ensure that the commercial spacecraft meets the required standards. However, absent a formal commitment, NASA has been unclear about what it plans to purchase from the commercial sector. This has led to a lack of clarity regarding what the actual return on investment will be for CLD operators.

Further, given the nascent state of current commercial demand, it is yet to be seen how the CCP model translates to other corporations. For SpaceX, a private entity already focused on space development without government incentivisation, the model worked effectively. However, the Boeing Starliner public-private attempt, developed based on a traditional government contractor model with limited investment by private parties, has not enjoyed the same success to date.

The CCP model needs to be further tested as it is still unclear if it works broadly or if it only worked in one instance. There may be a greater potential for success in new space-oriented companies in the Model but aspects of the CCP, like Firm Fixed Price contracting, may need to be altered or adjusted to more effectively meet scheduling and development goals. While the model is tweaked to fix potential inefficiencies, the government will likely need to continue to act as anchor tenant to foster the long-term sustainability of the commercial market.

Ultimately, further efforts to infuse a CCP-like framework into the CLD program should be supported by the current CCP Program. Given the amount of time, energy, and resources that NASA, SpaceX, and Boeing have invested to finding the balance between commercial autonomy and Government oversight through the CCP, this historical experience would aid in avoiding some of the growing pains the CCP experienced in its early days, and would likely streamline some of the implementation challenges discussed above. Infusing the CLD Program with NASA personnel with experience working CCP would seem beneficial.

ii. Applying A Proven Model to Commercial Space Stations

A multi-contract approach to the CLD framework allows for gradual steady growth of commercial trust in the CLD provider on behalf of both public and private sector customers. This is accomplished by drawing upon a long history of public-private space ventures. A tiered approach to the CLD framework through inception to implementation is evocative of the evolution of commercial space launch activities. Much like the CCP, the Development phase of a CLD demands a higher level of Government oversight. This ensures not only that Government customer needs are being addressed and lead to NASA successful qualification of the CLD provider's ability to provide service, but also that CLD operators can access the wealth of knowledge, technical expertise, and resources that NASA and other agencies may provide.

[18] Christopher J. Scolese, Charter of the Review of U.S. Human Space Flight Plans Committee, NASA (June 1, 2009), https://www.nasa.gov/offices/hsf/about/charter.html (last visited Oct. 17, 2024).

[19] National Aeronautics and Space Administration Authorization Act of 2010, Pub. L. No. 111-267 §§ 401(2)(7).

[20] Tariq Malik, President Obama Signs New Vision for U.S. Space Exploration Into Law, SPACE.COM (Oct. 11, 2010), https://www.space.com/9305-president-obama-signs-vision-space-exploration-law.html (last visited Oct. 17, 2024).

[21] What is Commercial Crew, NASA, https://www.nasa.gov/humans-in-space/commercial-space/commercial-crew-program/commercial-crew-program-overview/ (last visited Oct. 17, 2024).

IV. Recommendation: The Government should extend the FAA's commercial liability regime to Commercial Space Stations

The CLD Working Group identified ongoing liability concerns relating to the implementation and operation of CLD as the second key impediment to the success of commercial space stations. Namely, the commercial sector lacks the ability to feasibly mitigate liability exposure both due to lack of avenues for insurance and indemnification. The CLD Working Group advocates that Congress consider using the Federal Aviation Administration's (FAA) commercial liability regime, currently applied to space launches, as the blueprint to cover CLD.

At present, the CSLA is targeted toward launch and recovery and is not focused on on-orbit continuous operations. Given the identified need for CLDs, there is a pressing need for the expansion of the CSLA's scope. Under the CSLA and its subsequent amendments, the FAA provides licensing for commercial space launch and reentry activities.[22] The CSLA defines the Department of Transportation granted regulatory supervision over commercial spaceflight, indemnifies companies against significant third-party damages, and shapes the regulatory framework for commercial human spaceflight. The CSLA specifies an insurance requirement, specifically that commercial launch operators are required to "obtain liability insurance or demonstrate financial responsibility" to cover third party injury, including property damage, physical injury, and death, as well as any damage to Government property, capped at $500 million.[23] However, where a claim exceeds the required coverage amount, the Government agrees to indemnify up to "$1,500,000,000 (plus additional amounts necessary to reflect inflation occurring after January 1, 1989)" for additional damages on a case-by-case basis, and subject to Congressional assent.[24]

There is currently no comparable liability regime for CLD akin to the CLSA. This places a significant business unknown and burdensome risk on the CLD developers and future operators. Without such a regime, CLD contractors and other commercial space facility companies face substantial financial exposure and insurability uncertainties.

V. Recommendation: The Government should establish the LEO Accords as a normative mechanism for commercial space activity

Taking inspiration from the Artemis Accords which are a compilation of non-binding, multilateral agreements instituted by NASA and the US State Department in 2020, the CLD Working Group recommends the implementation of a set of LEO Accords. These LEO Accords are of particular importance given the commercial nature of the growing number and the global players entering in future earth orbiting space stations. All of these commercial stations will operate in legal contrast to the ISS, which was governed by Intergovernmental Agreement.[25] Thus, the LEO Accords would present a potential industry-level approach for norms setting to strive to achieve the establishment of non-binding–yet influential–principles promulgated at the Government level with ongoing Industry support and input. Such principles can act as a guide for creating an accepted set of international commercial standards.

A. Proven Effectiveness of Norms-Setting

Perhaps the most salient evidence of the effectiveness of norms-setting is the ongoing success of the Artemis Accords. Recognizing this ongoing and growing need for commercial support, the Artemis Accords evolved as a set of non-binding "political commitments" on a set of principles that ought to govern human activity in outer space.[26] The Artemis program sets forth two primary objectives: returning humans to the Moon and eventually sending them to Mars. To accomplish these, the program highlights the essential role of private companies in the future of space exploration. Further, the subsequent Artemis Accords serve as a modern example of how commercial interests are being integrated into international legal frameworks. With 42 nations across six continents having signed the Accords, their widespread adoption reflects a global commitment to advancing commercial space activities.

In 2024, the Artemis Accords had several notable updates and developments. Namely, a significant list of countries joined the Artemis Accords, bringing the total to 46 additional signatories as of October 2024.[27] Secondly, transparency and safety were

[22] 51 U.S.C. 50901 - 50923.

[23] 51 U.S. Code § 50914.

[24] 51 U.S. Code § 50915 (Adjusted for inflation, approximately $3.8B).

[25] Intergovernmental Agreement Among the Governments of Canada, the Federal Republic of Germany, Italy, Japan, the Russian Federation, the United Kingdom, and the United States on the International Space Station, Jan. 29, 1998.

[26] The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids, NASA (Oct. 13, 2020) [hereinafter Artemis Accords].

[27] Id.

emphasized at the International Astronautical Congress in Baku, Azerbaijan. Representatives from the signatories stressed the importance of disclosing information about mission plans, such as launch and landing dates, mission duration, and scientific activities. This effort aims to avoid interference and enhance the safety of lunar missions. Thirdly, the Artemis Accords continue to foster international collaboration, focusing on developing a sustainable and robust presence on the Moon. This includes sharing scientific data, ensuring the interoperability of systems, and providing emergency assistance, thereby creating a safe and cooperative environment for all participating nations. Lastly, regular workshops and meetings among signatories have been held to advance the principles of the Artemis Accords. These gatherings serve as platforms for discussing best practices, sharing progress, and addressing challenges related to lunar and space exploration.

The US space industry, both public and private, is at a pivotal moment where frameworks initiated domestically could influence the future of international law. By creating a regulatory and industry standards environment that supports businesses, the US not only helps its own companies advance new technologies but also makes its market more attractive to other countries seeking strategic partnerships. A Government-promulgated and commercially-supported set of LEO Accords would not only benefit both the Government and the commercial provider, but also provide clarity to the international community about the efficacy of CLD and encourage new and continued investment.

VI. Conclusion & Summary of Recommendations

The transition from the ISS to commercially operated space stations represents a pivotal moment for space activities. To ensure the success of Commercial Space Stations, a multi-contract approach is recommended. This approach would allow for gradual government disengagement, ensuring CLDs meet both public and private needs. Government entities like NASA would act as anchor tenant in the early stages, fostering trust in the CLD providers. Moreover, extending the Federal Aviation Administration's (FAA) liability regime, which currently covers space launches, to on-orbit operations would mitigate liability risks for private space companies. Finally, establishing a set of "LEO Accords" for low-Earth orbit activities, similar to the Artemis Accords for lunar missions, could further support normative frameworks in the burgeoning commercial space sector. By fostering public-private partnerships, adjusting regulatory frameworks, and implementing new liability protections, the government can support the commercial sector's growth and help ensure the sustainability of human space activity beyond Earth.

Summary of Recommendations:

1. **Adopt a multi-contract approach:** Commercial Space Station providers must balance public and private needs and interests to ensure efficacy and long-term sustainability.
2. **Extend the FAA's commercial liability regime:** The success of Commercial Space Stations hinges on the ability to mitigate liability exposure, which requires Government support and action to implement.
3. **Establish the LEO Accords:** As the Artemis Accords have shown, normative mechanisms provide a platform for identifying best practices and rules of the road for the future of commercial space activities.

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