TECHFREEDOM
LAW FOR A DYNAMIC FUTURE

In the Matter of

Request for Information	)
Cislunar Science and Technology Subcommittee	)
	)
National Science and Technology Strategy for	)
U.S. activities in cislunar space	)

Comments of TechFreedom

TechFreedom files these comments in response to OSTP's Request for Information on a national science and technology strategy for U.S. activities in cislunar space ("Cislunar RFI" or "RFI").[1] Founded in 2010, TechFreedom is a non-profit think tank dedicated to promoting the progress of technology that improves the human condition. To this end, we seek to advance public policy that makes experimentation, entrepreneurship, and investment possible, and thus unleashes the ultimate resource: human ingenuity. Wherever possible, we seek to empower users to make their own choices online and elsewhere.

TechFreedom, and the undersigned author, have almost 40 years' experience in outer space law and policy. A short list of our work includes Comments to NASA on its "Moon to Mars Objectives" and briefing of NASA officials in Houston, TX on July 28–29, 2022;[2] testimony before the U.S. Senate; amicus briefs in key court cases related to outer space law and policy; law review articles addressing key issues of space law; comments in agency proceedings on a variety of space-related issues; submissions to Congress and the White House on key space law and policy issues; and op-eds commenting on U.S. policy related to orbital debris.[3] We are therefore well-versed in issues related to a national science and technology strategy for U.S. activities in cislunar space.

The RFI asks two questions:

> 1. What research and development should the U.S. government prioritize to help advance a robust, cooperative, and sustainable ecosystem in cislunar space in the next 10 years? And over the next 50 years?

[1] The Cislunar RFI appeared in the Federal Register on July 6, 2022, 87 Fed. Reg. 40282 (July 6, 2022). The RFI sought comments by July 20, 2022. These Comments are timely filed.

[2] *See* Comments of TechFreedom, In the Matter of Moon to Mars Objectives, filed June 3, 2022, https://techfreedom.org/wp-content/uploads/2022/06/TechFreedom-Comment-Moon-to-Mars-6-3-22.pdf.

[3] For full citations to our prior work, *see supra* n.2.

2. What key technical standards are most useful to develop in support of activities in cislunar space, and how could these standards enable and support a vibrant and sustainable cislunar ecosystem?

I. Facilitating a Commercial Economy is the Key to Cislunar Development

We begin with Section 102(c) of the NASA Act: "the general welfare of the United States requires that the National Aeronautics and Space Administration (as established by title II of this Act) seek and encourage, to the maximum extent possible, the fullest commercial use of space."[4] The Commercial Space Act of 1998 uses the term "commercial" 72 times, including a requirement that "the Federal Government shall acquire space transportation services from United States commercial providers whenever such services are required in the course of its activities. To the maximum extent practicable, the Federal Government shall plan missions to accommodate the space transportation services capabilities of United States commercial providers."[5] Finally, in 2007, Congress added Section 20303(a), which directed that "[t]he Administration shall be a full participant in any interagency effort to promote innovation and economic competitiveness through near-term and long-term basic scientific research and development and the promotion of science, technology, engineering, and mathematics education, consistent with the Administration's mission, including authorized activities."[6]

The current National Space Policy echoes Congress's call to ensure that the economic impact of space activities and use of commercial capabilities should be front and center in OSTP's approach to research and development of cislunar space.

> Since America's first steps on the Moon, the United States has utilized its space capabilities to stimulate economic growth, enhance the quality of life for all Americans and people around the world, and advance the principles of democracy, human rights, and economic freedom. The United States shall: Extend human economic activity into deep space by establishing a permanent human presence on the Moon, and, in cooperation with private industry and international partners, develop infrastructure and services that will

[4] 51 U.S.C. § 20102. Subsection (c) was added by the National Aeronautics and Space Administration Authorization Act, 1985, Pub. L. No. 98-361, § 110(a), 98 Stat. 422, 426 (July 16, 1984). In 1990, Congress added Section 203(a) to the NASA Act, which states that "[t]he Administration, in order to carry out the purpose of this Act, shall—(4) seek and encourage, to the maximum extent possible, the fullest commercial use of space; and (5) encourage and provide for Federal Government use of commercially provided space services and hardware, consistent with the requirements of the Federal Government." National Aeronautics and Space Administration Authorization Act, Fiscal Year 1991, Pub. L. No. 101-611, § 107, 104 Stat. 3188, 3197 (Nov. 16, 1990).

[5] Commercial Space Act of 1998, Pub. L. No. 105-303, § 201, 112 Stat. 2843, 2854 (1998), codified at 51 U.S.C. § 50131(a).

[6] Pub. L. No. 110-69, title II, § 2001(a), (b), (c), (e), 121 Stat. 572, 582–83 (2007).

> enable science-driven exploration, space resource utilization, and human missions to Mars.[7]

A change in presidential administrations has not changed this emphasis on the economic development of outer space.

> We are in a historic moment: space activities are rapidly accelerating, resulting in new opportunities in multiple sectors of society, as well as new challenges to U.S. space leadership, global space governance, the sustainability of the space environment, and safe and secure space operations. Burgeoning U.S. space activities are a source of American strength at home and abroad—from providing tangible economic and societal benefits to Americans to expanding our network of alliances and partnerships.[8]

To remain consistent with both congressional mandate and U.S. policy, OSTP's focus in the current endeavor should be to both utilize existing commercial space capabilities *and* to foster research and development of new commercial capabilities in cislunar space. Science alone cannot be the ultimate driver for cislunar development.[9]

II. An "Apollo on Steroids" Approach to Cislunar Development, Where Science Is King, Will Fail

Any alternative to a commercially focused development of cislunar space is doomed to fail. A top-down, government procured program for developing cislunar space will suffer the same fate as each attempted return to the Moon since Apollo. Most notably, in the closest analog to the Artemis program, an "Apollo on steroids" approach failed with President George H. W. Bush's 1989 Space Exploration Initiative (SEI).[10] Thor Hogan summed up the failure of SEI in his book *Mars Wars: The Rise and Fall of the Space Exploration Initiative*:

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[7] NATIONAL SPACE POLICY OF THE UNITED STATES OF AMERICA 1, 5 (Dec. 9, 2020), https://trumpwhitehouse.archives.gov/wp-content/uploads/2020/12/National-Space-Policy.pdf.

[8] THE WHITE HOUSE, UNITED STATES SPACE PRIORITIES FRAMEWORK 3 (Dec. 2021), https://www.whitehouse.gov/wp-content/uploads/2021/12/United-States-Space-Priorities-Framework-_-December-1-2021.pdf.

[9] One thing has been clear for many decades, if not centuries: the lure of scientific discovery alone will never garner sufficient political or public support to result in government appropriations necessary to carry out major exploration projects. When President Thomas Jefferson underwrote an expedition to explore the lands acquired by the United States in the Louisiana Purchase, he sent Meriwether Lewis detailed instructions as to the purposes of the expedition. While Jefferson was interested in acquiring scientific knowledge of the area (indeed, it can be argued that he was our most scientifically literate president), "The object of your mission is to explore the Missouri river, & such principal stream of it, as, by it's [sic] course & communication with the water of the Pacific Ocean may offer the most direct & practicable water communication across this continent, for *the purposes of commerce*." Letter from Thomas Jefferson to Meriwether Lewis (June 20, 1803), https://www.loc.gov/exhibits/lewisandclark/transcript57.html.

[10] *See* Steven Dick, *The Space Exploration Initiative*, NASA, https://history.nasa.gov/sei.htm (last visited June 2, 2022).

> The rise of SEI and its eventual demise represents one of the landmark episodes in the history of the American space program… It is a tale of organizational, cultural, and personal confrontation. Organizational skirmishes involved the Space Council versus NASA, the White House versus congressional appropriators, and the Johnson Space Center versus the rest of the space agency—all seeking control of the national space policy process.[11]

A recent NASA OIG Report appears to signal that NASA's Artemis program may be headed toward the same failure mode.

> For FYs 2021 through 2025, the Agency uses a rough estimate for the first three missions that excludes $25 billion for key activities related to planned missions beyond Artemis III. When aggregating all relevant costs across mission directorates, NASA is projected to spend $93 billion on the Artemis effort up to FY 2025. We also project the current production and operations cost of a single SLS/Orion system at $4.1 billion per launch for Artemis I through IV…. Multiple factors contribute to the high cost of ESD programs, including the use of sole-source, cost-plus contracts; the inability to definitize key contract terms in a timely manner; and the fact that except for the Orion capsule, its subsystems, and the supporting launch facilities, all components are expendable and "single use" unlike emerging commercial space flight systems. Without capturing, accurately reporting, and reducing the cost of future SLS/Orion missions, the Agency will face significant challenges to sustaining its Artemis program in its current configuration.[12]

Previous planning bodies, even though they've been unsuccessful in garnering sufficient support for humans in deep space, at least recognized that economic development of space must be a key driver to gain sufficient public and political support. The 1986 National Commission on Space report, *Pioneering the Space Frontier: An Exciting Vision of Our Next Fifty Years in Space*, for example, listed three overarching goals for space exploration and development: "'pulling-through' advances in science and technology of critical importance to the Nation's future economic strength and national security… providing direct economic returns from new space-based enterprises that capitalize upon broad, low-cost access to space, and…

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[11] Thor Hogan, *Mars Wars: The Rise and Fall of the Space Exploration Initiative* at 2, NASA (May 2007), https://history.nasa.gov/sp4410.pdf (footnote omitted).

[12] NASA OFFICE OF INSPECTOR GENERAL, NASA'S MANAGEMENT OF THE ARTEMIS MISSIONS at 3–4, (2021), https://oig.nasa.gov/docs/IG-22-003.pdf. The Report also indicated that the projected $3.592 billion budget for the Lunar Gateway may understate the ultimate cost by a considerable amount. Moreover, what began as a firm-fixed-price contract for the HALO element has now morphed into "a sole-source undefinitized contract with only its design phase definitized 10 months later as a cost-plus-incentive-fee due to anticipated future design changes." NASA OFFICE OF INSPECTOR GENERAL, NASA'S MANAGEMENT OF THE GATEWAY PROGRAM FOR ARTEMIS MISSIONS at 18, (2020), https://oig.nasa.gov/docs/IG-21-004.pdf.

opening new worlds on the space frontier, with vast resources that can free humanity's aspirations from the limitations of our small planet of birth."[13]

III. Establishing a Commercial Cislunar Economy Will Drive Down Costs and Allow for More Rapid Development

In contrast to a top-down, government-run approach where the government continues to pump money into programs until they are successful regardless of cost, stands the approach of government setting up general parameters and then purchasing commercial solutions. The differences are staggering. SLS is clocking in at over $4 billion per flight. The James Webb Space Telescope (JWST) was supposed to cost $500 million and be launched by 2007. It was finally launched at the end of 2021, and cost $10 billion.[14] These two programs, done in the traditional style of cost-plus contracting, have been a massive drain on NASA's budget, effectively keeping the development of cislunar space beyond the financial ability of out government. When governments instead turn to private enterprise to provide the goods and services they need, costs plummet.

Procurement programs fashioned after the Commercial Orbital Transportation Services (COTS) program are the only viable way to develop an actual cislunar economy. The COTS Final Report found the following, which can be applied directly to cislunar development: 1) Government seed money was highly leveraged—Commercial partners funded over 50% of COTS development costs; 2) Fixed-price milestone payments maximized incentives to control cost and minimize schedule delays; 3) Minimum firm requirements along with commensurate Government oversight were key to fostering innovation and reducing life cycle development costs; 4) Goals (vs. requirements) were established to open trade space and optimize design (Firm requirements were identified only where necessary to assure the safety of the ISS and crew, and ISS interface requirements evolved over time and were coordinated in a collaborative manner with the commercial partners); 5) A portfolio of multiple partners with different capabilities assured a balanced approach to technical and business risks; 6) Commercial friendly intellectual property/data rights and limited termination liability encouraged investment of private capital; and 7) NASA commitment to purchase operational services greatly improves the ability for companies to raise funds.[15]

The 2017 Air Force Fast Space Study summarized the importance of using Other Transaction Authority (OTA) as follows:

> FINDING [F.4] Traditional USG acquisition methods, or a traditional operationally-focused acquisition office, are likely to fail at effectively partnering with

[13] NATIONAL COMMISSION ON SPACE, PIONEERING THE SPACE FRONTIER: AN EXCITING VISION OF OUR NEXT FIFTY YEARS IN SPACE 19 (1986).

[14] Kishalaya Kundu, *How Much Did The James Webb Space Telescope Cost?*, SCREENRANT (May 11, 2022), https://screenrant.com/james-webb-space-telescope-cost-how-much/.

[15] *See COTS: Final Report*, NASA, https://www.nasa.gov/content/cots-final-report (last visited June 2, 2022).

> commercial space industry. The majority of leading US commercial firms have made it very clear they are not interested in traditional USG FAR-contract-based approaches to accelerate private development of ULCATS systems. Traditional USG methods of buying launch services have been optimized for removing residual levels of risk, not for lowering costs. The current USG methods of mission assurance are completely rational in an industry where the cost of the spacecraft is several times the cost of the launch and the consequences of a failed launch can be catastrophic to national security. USG agencies that implement these important methods of mission assurance have cultures, processes, and values that are in complete alignment with this philosophy of space launch. These same processes, cultures and values—which are critical to these agencies' ability to eliminate the residual risk from expendable launch vehicles—are showstopping-barriers to the commercial innovation process.[16]

Yes, private companies can fail and negatively impact the overall development of cislunar space. But with broader commercial involvement and lower costs, governments can hedge their bets by selecting multiple commercial providers, spreading the risk, while still saving substantial money.[17]

Establishing a robust commercial cislunar economy is also in the long-term strategic interest of the United States. China has not hidden its aspirations to dominate cislunar space.[18] Our best defense is our strongest asset – the ability of our private sector to innovate and compete.

IV. Specific Development Goals

In conjunction with private partners, the U.S. government should support the following research and development topics:

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[16] AIR UNIVERSITY, MAXWELL AFB, FAST SPACE: LEVERAGING ULTRA LOW-COST SPACE ACCESS FOR 21ST CENTURY CHALLENGERS 33–34 (2017), https://www.airuniversity.af.edu/Portals/10/Research/Space-Horizons/documents/Fast%20Space_Public_2017.pdf (declassified version).

[17] For example, Masten Space Systems, one of the Commercial Lunar Payload Service (CLPS) winners appears to be in grave financial trouble and may not be able to ultimately perform on its $76 million NASA contract. *See* Douglas Messier, *Cash-strapped Masten Space Furloughs Employees, Moon Landing Mission at Risk*, PARABOLIC ARC (July 14, 2022), http://parabolicarc.com/2022/07/14/cash-strapped-masten-space-furloughs-employees-moon-landing-mission-at-risk/. This would be troubling were this a sole-source, cost-plus contract. Because there are multiple other CLPS awardees, however, NASA has spread the risk, while still saving a significant amount of money compared to if it had developed the lunar landing system itself. *See* https://www.nasa.gov/content/commercial-lunar-payload-services.

[18] U.S.-China Economic and Security Review Commission, Report to Congress of the U.S.-China Economic and Security Review Commission 16 (2019), https://www.uscc.gov/sites/default/files/2019-11/2019%20Annual%20Report%20to%20Congress.pdf.

1. Reduce "regulatory friction" by streamlining agency rules and licensing procedures, allowing for an increased cadence of flights and payloads;[19]
2. A robust communications system (including, where necessary, ITU and domestic spectrum allocations and licensing regimes to allow for commercial licenses);
3. In Situ Resource Utilization (ISRU). A robust cislunar economy cannot develop without techniques to "live off the land."
4. Power and power transport.
5. Accurate lunar polar maps. It is our understanding that the current maps of the poles are "best guesses" of the topography of the surface. If we are to discover and mine the water resources at the poles, we must have more accurate maps;
6. Commercial launch and landing pads on the Moon, especially at the poles, where there may be significant traffic congestion. Ingress and egress to the poles may result in significant ejecta damage from rocket exhaust without a well-developed plume containment system.
7. Orbital fuel depots. Transportation systems within the cislunar system will need "gas stations" along the way. Carrying all fuel throughout a journey (wherever that be within the cislunar system) will make travel exorbitantly expensive. By developing waystations with standardized refueling methods and hardware, we can significantly lower the transportation costs.
8. Low delta-V "cycler" transportation systems to further lower transportation costs.[20]
9. Research use of lunar lava tubes for habitats to guard against the harsh lunar radiation environment.

In all of these areas, the government should support basic research efforts, but fully engage with commercial industry to both draw from their expertise and develop exit strategies to fully transition the technology to the private sector for commercial implementation.

Respectfully submitted,

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[19] *See* FAST SPACE STUDY, *supra* n. 16, at C-3 ("While public law for commercial space transportation has evolved beneficially over 3 decades, the regulations which implement it have not, and lag far behind technological and business developments. As such, the government organizations and processes that deal with launch providers are still largely aligned with launch being a high-cost, infrequent, risky, and very specialized activity.").

[20] C. Uphoff & M. A. Crouch, *Lunar Cycler Orbits with Alternating Semi-Monthly Transfer Windows*, COMPUTATIONAL MISSION ANALYSIS (2002), https://cbboff.org/UCBoulderCourse/documents/LunarCyclerPaper.pdf.