

**House Committee on Science, Space, and Technology
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**Statement for the Record
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Chairman Haridopolos, Ranking Member Foushee, and distinguished members of this Subcommittee. Thank you for holding this important hearing.

A new Congress and a new Administration provide a timely opportunity to consider the American space enterprise – and in particular, the role of human space exploration in service to U.S. national interests.

I have a written statement that I ask your permission to be including in the hearing record but will endeavor to keep my oral statement brief.

Recent History

After the loss of the Space Shuttle *Columbia* in 2003, the United States chose to complete the International Space Station, retire the Shuttle program, and set a new direction for human space missions beyond the Earth, first the Moon, then Mars. The Congress passed back to back, bipartisan NASA authorization bills in 2005 and 2008. Such consistent, bipartisan support is incredibly important to long-term efforts such as space exploration.

NASA took a detour during the Obama Administration, with the deletion of human lunar return and its replacement with an Asteroid Retrieval Mission and an ill-defined, unilateral “Journey to Mars.” On a bipartisan basis, members of Congress were uncomfortable with the new direction from the White House, leading to a very contentious fight over the 2010 NASA authorization bill.

While a fan exploring Mars and asteroids, I was also opposed to the “Journey to Mars” concept as it lacked a clear program and did not provide a meaningful path for international or commercial participation. As a result, you could see other countries withdrawing from us, leading to geopolitical harm to U.S. interests in space. In 2017, the Trump Administration issued Space Policy Directive 1, which reflected a return to the bipartisan consistency of the Moon then Mars. SPD-1 also recognized the necessity of international and commercial partnerships, both of which had become far more capable than the Moon-Mars proposals for the Bush 41 and Bush 43 Administrations (i.e., the Space Exploration Initiative, and the Vision for Space Exploration, respectively).

We know space is vitally important to the United States. But the space domain is not subject to the kind of direct control possible with land, sea or air domains. So how can the United States protect its interests and values? The answer, in part, is through international leadership. International leadership in space today is different than during the Apollo era. Sixty years ago, the point was to show what the United States, and only the United States could do. Today, space leadership is about having other countries wanting to work with you, to be a partner in common endeavors. In doing so, we can shape activities in the space domain in a manner conducive to the interests of the United States, its allies, and like-minded partners.

A sustainable space policy is one which is aligned with enduring national interests, not a particular party or personality. In signing SPD-1 in 2017, President Trump said “Beginning with missions beyond low Earth orbit, the United States will lead the return of humans to the Moon for long term exploration and utilization, followed by human missions to Mars and other destinations.” This direction is technically sound in its inclusion of both the Moon and Mars in U.S. human space exploration objectives. It is practical in its reliance on commercial partnership and innovation. Finally, it is geopolitically sound in its use of international cooperation to shape the environment upon which the United States relies and in which it competes.

President Reagan’s 1988 National Space Policy said that the goal of human space exploration was to “to expand human presence and activity beyond Earth orbit into the solar system.” In doing so, the United States would not be choosing between humans or robots. We need both. We would not be choosing either the Moon or Mars. We need both. President Reagan’s direction, like President Trump’s, was not about “flags and footprints” but about the expansion of humanity and the United States in particular. The nation conducts dangerous and expensive exploration missions to advance the interests and values of the United States. Such missions should be conducted in a way that enhances our security, strengthens our economy, encourages others to align with us and our values, gains knowledge and skills and inspires the next generation.

Immediate Challenges

There are several immediate challenges for U.S. space exploration, such as ensuring more than one way of getting Americans to orbit, managing the end of the International Space Station and transitioning to one or more private platforms, creating a sustainable return to the Moon, and building the capabilities needed to place Americans on Mars and return them safely to Earth.

For over twenty years, Mars has been the official goal of U.S. human space exploration and this is reflected in the current National Space Policy of 2020. Nonetheless, more can be done to advance Mars exploration. There are planetary launch “windows” in 2026 and the last quarter of 2028/first quarter of 2029. Elon Musk has said he will try to land unmanned Starships on Mars using the first. If successful, he would try for a crewed mission using the second window. I am clearly not Elon Musk, but I do see one-way, unmanned landings as feasible while I am skeptical of a successful human landing on Mars in the next five years. At the extreme, a robotic

return Mars soil samples or a human fly-by of Mars (like the Apollo 8 mission to the Moon) may become feasible.

While thinking about Mars missions, we should be mindful of China. They have their own space station, they have landed robots on the Moon and Mars, and they are planning to put humans on the Moon and return samples from Mars. It is entirely possible that they could beat us in achieving these latter two tasks.

The United States landed on the Moon over 55 years ago. But we should not want to see China on the Moon before we're able to return. More importantly, we need to be able to have a sustainable lunar presence – sustainable technically, economically, and politically. Norway was the first to reach the South Pole, but today it is the United States that puts some 3,000 persons “on the ice” each year. Through its presence, the United States shapes and guides the Antarctic Treaty System for that remote continent today.

As a consequence, I'd like to share two concerns for U.S. human space exploration. First, we should pay attention to geopolitical conditions and competition in order to ensure our space efforts support our larger national interests. Second, for U.S. leadership to be effective, human space exploration missions cannot be “one and done” but must be repeatable and sustainable, with continuous presence as the norm. These conditions lead to space architectures whose elements are reusable, with in-space utilities for power, communications, and navigation, advanced biomedical knowledge, and the use of in-space resources (e.g., lunar water ice, asteroids).

The current Artemis program presents very complex challenges, especially for the systems engineering and integration required to incorporate commercial and international partner contributions. A primary concern is the Space Launch System (SLS), which is not reusable. It has had one flight, but has trouble supporting one flight per year, much less congressional targets of two “cores” per year. A second mobile launch platform (MLP-2) and the Exploration Upper Station for the SLS Block 2 are behind schedule. Cores for the Artemis 2 and Artemis 3 missions, involving crews flying around the Moon and then landing, are well along. But it is time to consider alternatives for going from the Earth to the Moon and returning.

We need an off-ramp for reliance on the SLS. Ideally, NASA should be able to buy heavy lift services to send payloads to the Moon – up to about 45 metric tons to “trans-lunar injection” which is about the same performance as the SLS Block 2. I was a supporter of SLS when it was created as NASA required heavy-lift vehicles to send humans to the Moon and Mars. At the time, it did not appear (to me) that a private sector heavy-lift vehicle would be feasible within two decades. Today, the situation is different, with heavy-lift options from SpaceX, Blue Origin, and United Launch Alliance.

A revised Artemis campaign plan should be a high priority for the new NASA Administrator. There may be some painful adjustments with industry and our international partners, but it is better to do so now than to continue on an unsustainable, unaffordable path. The Artemis

policy is a good one, supported by Congress and multiple administrations. However, we need a more sustainable and credible approach so that NASA, industry, and our international partners can make good decisions.

The need for reassessing a major space program is not unique. In 1993, the Space Station Freedom program survived by only one vote in the House. The Clinton Administration came close to cancelling the program but instead chose to partner with Russia in what became the International Space Station. The policy goal of having a space station did not change, but how it was implemented changed drastically. Today, the Artemis program can and should be reformed to fulfil the policy goals of SPD-1. This time, instead of the Russians, we can benefit from a powerful and innovative U.S. private sector and allied spacefaring powers such as Japan and Europe.

NASA needs to focus on those things that make no sense for the private sector to do while using the private sector to improve what NASA does. NASA has critical roles to play in science, technology development for unique, government missions, and developing infrastructure. Through lunar operations, we will build experience and capacity for Mars. The creation of private communications, navigation, and power systems on and around the Moon will feed forward to Mars. New nuclear power sources, a solar system wide internet and the use of local resources can make habitation of the Moon and Mars as sustainable as being in Antarctica is today.

We are and have been headed to Mars. We can certainly say more about this goal as the President has directed. We are not engaged in a one-time race of “one and done” but a long-term expansion of the American dream. We can argue over relative levels of effort exploring the Moon or Mars or asteroids, but we need both. In order to reap benefits for the American people, we need to bring others with us, pushing technology, and promoting economic development. And not become bogged down at one physical destination or with any one technical concept.

Major Recommendations

Policy Stability: The current U.S. policy is to retire the International Space Station by 2030 and return humans to the Moon before then should be maintained. The geopolitical context and rationale for human space exploration should be clearly understood.

NASA Funding: The NASA budget has been in decline in real dollar terms since the end of the Cold War. If NASA were to have the same buying power today as it did in 1992, its budget would be over \$30 billion. In order to justify more resources, NASA needs to innovate more, reduce costs associated with fixed and aging infrastructure, and leverage the private sector to create new capabilities it will want to buy. While ensuring “dissimilar redundancy” for critical capabilities such as lunar landing and crew launch, traditional programs of record should be used only as a last resort.

International Space Station: The station is doing useful scientific work and is being well-utilized, however, its age and increasing number of small anomalies requires continued vigilance to ensure crew safety. It is possible that the ISS may need to end before 2030. This would leave China as the only country with an operational space station. To ensure no gap in U.S. presence in low Earth orbit, NASA is pursuing contracts to spur private development of space platforms on which NASA could be one of several customers. However, NASA has not provided sufficient funds or set clear priorities for these platforms, unlike what it did for the development of commercial crew and cargo capabilities. Efforts to create private LEO platforms should be funded, with efforts to begin transitioning NASA work to them as soon as practicable.

Artemis Program: NASA needs an integrated exploration campaign plan with detailed systems engineering for a simpler, more sustainable architecture. After the decision was made in 2019 to return to the Moon by 2024, NASA was tasked by the National Space Council and Congress to produce such a plan. NASA produced a plan for Artemis missions 1-4, but NASA continues to have difficulty with questions about who will do what, when, and why. An enterprise campaign planning team should be created as part of the Congressionally-mandated Moon-to-Mars program office. This effort can be augmented by NASA Centers and FFRDC/UARC capabilities. The Exploration Campaign Planning Team should be tasked to produce an integrated campaign plan and then periodically updated.

Heavy-lift Space Launch Capability

The United States should seek to use commercial providers for heavy lift capabilities that can sustain multiple crew and cargo missions each year to the Moon. The Space Launch System can be phased out as one or more sources of private heavy-lift are demonstrated.

NASA Infrastructure: NASA is at a crossroads regarding the number and size of facilities it will need in the future as the agency expands its hybrid work environments following the pandemic. Fixed infrastructure costs are a major burden on the agency that competes with funding scientific and exploration missions. Deferring maintenance until equipment fails has resulted in repair and replacement costs up to three times more than had NASA conducted regular maintenance. The NASA Administrator should initiate a streamlining of NASA-wide institutional overhead in the form of workforce and facilities. In coordination with the Chief Financial Officer and Human Capital Officer, an intense effort should seek to identify opportunities for a) significant personnel reductions and transfer; and b) consolidation of Center capabilities whose overhead is charged to infrastructure. Saved resources would be reallocated to program offices, with Artemis as the first priority, followed by maintaining a continuous crewed American presence in LEO, science, and aeronautics missions.

Space Nuclear Power: Nuclear power is essential for human and robotic deep space missions. NASA, and commercial nuclear technology developments can benefit each other by lowering risks and costs, thus enabling NASA to acquire necessary power and propulsion capabilities without having to support dedicated and separate technology programs. These private systems need an effective licensing system, yet only two new reactors have been licensed in the United States since 1978. In addition, the Nuclear Regulatory Commission lacks legislative authority to

license commercial nuclear reactors in space. Such legislation was proposed in the Senate in past years but has never made it out of Committee. An existing Presidential Memorandum (August 20, 2019) already addresses the conditions for the launch of spacecraft containing nuclear systems. NASA, DOD, and DOE should propose a pilot acquisition program for space-based uses of nuclear fission reactors.

Humans to Mars: The technologies and practices needed for Mars can and should benefit operations in Low Earth Orbit and at the Moon. Examples include artificial intelligence enabled networks of satellite servicing, repair, and refueling robots with unprecedented levels of precision and accuracy; fully-automated re-entry and landing systems for crew and priority cargo; new families of electric and chemical engines designed to operate only operate in space; inexpensive, radiation hardened electronic components; zero boil-off cryogenic fuel depots; and artificial gravity space stations. All of these can benefit from private sector innovation given the right demand signals from government.

Strategic Choices for the Future

Seemingly separate areas of America's space enterprise – scientific, military, commercial, international, are deeply linked to each other. Large commercial and military constellations are driving high launch rates that are lowering launch prices. Price declines are enabling new space applications and the commercialization of Low Earth Orbit.

Private investments in the expansion of commercial space industries are creating new capabilities that will enable humans to return to the Moon and establish a permanent presence on Mars. The expansion of space activities of all kinds will create new international challenges and opportunities for governance of space and its resources.

In the near-term, the Artemis program is a key element in shaping the geopolitical environment of space. It is not a military program, but it supports national security purposes. The rules of the space environment will be made by those who show up, not by those who stay behind. In the longer term, the expansion of American and allied activity beyond the Earth and into the solar system can be likened to the imperative of building the transcontinental railroad in the 19th century.¹

When the Pacific Railroad Act was passed in 1862, in the middle of the American Civil War, California had only been a US territory for a little over a decade. Americans loyal to the Union were by no means the majority of the population and no regular troops were present. British forces were stationed in British Columbia, Russian forces in Alaska, French forces in Mexico, and Confederate forces in Tucson were all closer in distance and travel time than any Union regulars.

The project was a high technological risk. No railroad of that length had been built anywhere or had climbed mountains as high as the Rockies. There was no obvious source of useful freight or

¹ This idea is from a forthcoming paper by James C. Bennett.

passengers for the greater part of the distance, except for a few Army forts. Aside from gold and silver, there were no obvious products in California that could provide freight revenues back to the East Coast.

To raise funds, the Pacific Railroad Act provided subsidies in the form of a fixed sum per mile of track laid, and land grants in the form of alternate squares of land, checkerboard style, along the route. The subsidies to the railroad companies provided working capital, and the land grants gave investors the prospect of a large eventual profit. The land along the Pacific Railroad route had almost zero dollar value before the railroad, while most of it gained far more value once it had transportation. The railroad and its shareholders never really got rich from freight tariffs and passenger fares. However, they got very rich from the sale of land grants once the areas became populated, and from all the other economic activity the railroads stimulated.

In the near-term, lunar settlements might be similar to Antarctic research stations. In the longer term, those settlements and those on Mars have the potential to be entirely new communities much as the Great American Desert was transformed by the coming of the railroad. While there are massive technical, economic, and biological uncertainties, the vision of becoming a multi-planetary species is certainly an exciting one. The goal of “Mars” is not just a race but can be thought of as a shorthand term for much bigger, indefinite objectives for America’s future.

Mr. Chairman, in closing, I would like to include text from a 2020 report from the National Space Council, “A New Era for Deep Space Exploration and Settlement.” The purpose of this document was to describe, much like a congressional report, the context and motivation for the space policy directives approved by the President. To quote:

“The long-term policy of sustainable space exploration and development depends on alignment with enduring national interests such as security, economic growth, scientific advancement, and a stable international environment. As new information comes to light and new experiences are gained, the United States should be prepared to adapt to new opportunities and risks. Although we are not in a Cold War-era space race, space exploration and development are urgent issues. The international environment is dynamic and influenced by competition and threats to the space capabilities on which we rely. Consequently, it is important that U.S. space activities across the civil, commercial, and national security sectors be coordinated at the highest levels and in an integrated manner to advance our holistic interests and those of our international allies. Establishing U.S. capabilities to operate routinely in cis-lunar space and beyond will deliver strategic assets not only for ourselves, but for all like-minded nations who share our values – liberty, democracy, the rule of law, and free market economic principles.

Exploration is fundamental to the American spirit, and space exploration is the modern embodiment of early frontier expeditions. It is the next step in a never-ending quest to explore and develop the unknown, while securing benefits for the American people. Space exploration and development are not confined to one-time missions or any single destination. Rather, the effort described here is one of continually expanding human activity beyond the Earth. Close to home, the United States will encourage commercial activities to lower the public burden of

maintaining and enhancing space capabilities. As the United States journeys into deep space again, it will do so with commercial and international partners as they are willing to participate and capable of participating. At the frontiers of exploration, the United States will continue to lead, as it has always done, in space. If humanity does have a future in space, it should be one in which space is the home of free people.”

Thank you for your kind attention. I look forward to your questions.