

**THERE'S A BAD MOON ON THE RISE:
WHY CONGRESS AND NASA MUST THWART
CHINA IN THE SPACE RACE**

HEARING

BEFORE THE

**COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE**

ONE HUNDRED NINETEENTH CONGRESS

FIRST SESSION

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED NINETEENTH CONGRESS

FIRST SESSION

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**THERE'S A BAD MOON ON THE RISE:
WHY CONGRESS AND NASA MUST THWART
CHINA IN THE SPACE RACE**

WEDNESDAY, SEPTEMBER 3, 2025

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:30 a.m., in room SR-253, Russell Senate Office Building, Hon. Ted Cruz, Chairman of the Committee, presiding.

Present: Senators Cruz, Fischer, Moran, Sullivan, Blackburn, Young, Schmitt, Moreno, Sheehy, Cantwell, Klobuchar, Peters, Rosen, Luján, Hickenlooper, Fetterman, and Kim.

**OPENING STATEMENT OF HON. TED CRUZ,
U.S. SENATOR FROM TEXAS**

Chairman CRUZ. Good morning. The Senate Committee on Commerce, Science, and Transportation will come to order.

Today, we will discuss NASA's progress, its challenges, and the path forward on the first comprehensive NASA authorization bill since 2017.

When I was Chairman of this Committee's Space Subcommittee, Senator Bill Nelson and I worked together on several pieces of space legislation that were signed into law by both President Obama and President Trump. Continuing that bipartisan tradition, this past March, my colleagues and I together introduced a short-term NASA authorization bill.

All these efforts reveal an important truth, which is this: there exists a strong, bipartisan consensus in Congress for backing the critical mission of NASA. When it comes to the final frontier, we are not Republicans or Democrats. Rather, we are Americans first, and all of us know that for our Nation to continue doing incredible things in space, we must rely on and empower NASA's ingenuity and determination.

NASA has always been one of America's greatest engines of innovation. From Apollo to Artemis, from the Space Shuttle to the International Space Station, our space program reflects the very best of American leadership.

I look forward to continuing that tradition by working and enacting into law a longer-term reauthorization of NASA with my colleagues.

This is a pivotal moment for our Nation's space programs. America must maintain leadership in low Earth orbit, while also em-

barking on a new era of exploration with Artemis. Make no mistake: we are in a new space race with China, and if we fail, there will be a bad moon on the rise.

China has made no secrets of its goals. It is investing heavily in its space capabilities, maintaining a permanent presence in low Earth orbit, and working to plant its flag on the Moon by 2030.

The stakes could not be higher. Space is no longer reserved simply for peaceful exploration. It is today a strategic frontier with direct consequences for national security, economic growth, and technological leadership. If our adversaries achieve dominant space capabilities, it would pose a profound risk to America. This is not just about exploration. The choices we make today will determine whether the United States leads in space or cedes space to an authoritarian regime.

That is why continuity in NASA's programs is not simply good practice. It is a matter of national security. Any drastic changes in NASA's architecture at this stage threaten United States' leadership in space. Delays or disruptions only serve our competitors' interests.

Congress has spoken clearly on this matter. In the One Big Beautiful Bill, which I was proud to champion, we reaffirmed strong support for NASA's exploration programs.

At a time when some have sought to prematurely dismantle the International Space Station—despite China's presence in low Earth orbit—Congress provided ample funding to continue the safe operations of the ISS as well as provide an on-ramp for follow-on commercial stations.

And Congress also provided the funds necessary to sustain a presence on the Moon. Artemis IV will deliver and assemble the first major elements of the Gateway station in lunar orbit, and Artemis V will expand surface exploration using that platform. These missions rely on the Space Launch System and Orion capsule to reach the Moon and to reach the Gateway station.

It would be folly to cut short these missions after much of the hardware has already been purchased and, in some cases, delivered with no commercial alternative readily available. I look forward to working hand-in-hand with the Administration to ensure those funds are utilized in full accordance with congressional intent.

We have seen overwhelming support for maintaining these programs from Senators, Republicans and Democrats alike. Congress supports NASA's exploration goals, and we do not want sudden or disruptive changes that undermine America's leadership.

NASA is more than just a symbol of national pride. It is a strategic capability that advances our economy, security, and values. The milestones ahead, maintaining continuous human presence in low Earth orbit, returning American astronauts to the Moon, landing the first female astronaut in history on the surface of the Moon—as the father of daughters that is particular near and dear to my heart—and preparing for human missions to Mars, these are not just scientific achievements. They are fundamental to America's role as the world's leading spacefaring nation.

America must remain the world leader in space. With steady leadership and clear direction, I am confident we will.

I now turn to Ranking Member Cantwell.

**STATEMENT OF HON. MARIA CANTWELL,
U.S. SENATOR FROM WASHINGTON**

Senator CANTWELL. Thank you, Mr. Chairman, and I am glad to join you today in this fight to say we must maintain our focus on returning to the Moon. It is good to see the witnesses here, Mr. Cutler, Mr. Gold, Mr. Bridenstine, and Lieutenant General Shaw. But I also want to recognize Bill Nye, also a Northwest Planetary Society individual, who is here today as well. I look forward to all of your testimony.

Today we are here in a race with China to return to the Moon and stay there. Beating China back to the Moon is not just about bragging rights, and it is certainly not just about grabbing headlines. But today, it is clear that President Xi, President Putin, and Prime Minister Modi are all in China having a big national security and strategic discussion that could easily—easily include space and defense and security and defense implications.

No surprise actually, that Kim Jong Un is also there. Let's just take for a consideration that he would like to figure out how to improve his rocket technology with more accuracy, more distance, more tracking. I don't like the scenario.

The strategic value of maintaining our position to live and work in space is critical. It is critical to our future economic and national security. Returning to the Moon requires us to push the limits of technology to find the solutions that we can solve and maintain our national defense and innovation economy. All you have to do is look back to the 1960s and look at the development of technologies that created an ecosystem within the United States of America that led to discoveries and innovations that we are still now counting on today.

So, we must not waver in this important mission of technology and national security defense. I believe each of the witnesses will tell us something about this today and why the consequences of failing to achieve this goal will be monumental. We know we need to go back to the Moon, and we know we need to go there before China establishes a permanent presence. I want to hear, importantly, about the expertise these individuals think that we must pull together so that we will not fall short of this goal. It is clear in some of your testimony, you are already articulating the strategic advantage China has of being so uniform on their government structure. We, on the other hand, are trying to work both within the government and within the commercial sector, on a partnership that allows all of us to creatively work together and move forward.

That is why, Lieutenant General Shaw, I found your statement in your testimony quite compelling, quote, "I believe if we do not unify and synchronize our efforts, we will find ourselves rather than the space leaders we are today, instead in a position of increasing disadvantage in space as we progress further into this century," end quote. I don't want to see that reality either. I want us to explore how to get the most out of NASA's commercial partnership and determine if sufficient redundancy in the provisions of commercial space are there to ensure that.

The state of Washington plays a very proud role in the exploration of space and the space economy—about 77,000 people employed today, just in the space economy, obviously, more than

100,000 employed in aerospace in general. So these are important companies to us, Aerojet Rocketdyne, Boeing, Blue Origin, all working on rocket infrastructure, crew capsules, Gateway lunar landing orbit stations and human landers. All of these are so important.

And also just a shout-out to the returning Colonel Anne McClain from Spokane, who just returned from serving as the Commander on the ISS mission from March through August of this year. So yes, we have a lot of people thinking about space in the Northwest.

So I am concerned about the current plan and what we are doing to make sure that we continue to push forward. I would love to see the continued focus on dual landers, given how important they are going to be for the future. It is not just one time. It is many times. This is an operation where we are going to continue to return and be an operational system. So I want to make sure that we have the best. I want to make sure that NASA has backup plans that takes advantage and ensures that the already delayed mission does not slip any further.

I don't know that it takes a genius to figure out that while China may be projecting 2030, or some time period, there is nothing to say that they won't go sooner. There are people we talked to in trying to brief the press about this today, who are betting that they are going to go sooner and that they are going to beat us.

So we don't need another Sputnik moment. It has already happened. The only thing we have to do is make sure we in Congress get the budget right and support the Artemis mission. I appreciate everything the Chair has done in putting money toward the Artemis mission, and I appreciate everything that we are doing collectively to assure that the Administration spends it.

But I also want to point out that, as Lieutenant General Shaw also says, this whole cislunar communication architecture—that is, the space between the Earth and the Moon—that is what China would love to do, go dominate the communication system between the space and the Moon. That is what they are already working on. We cannot allow that to happen. We need to continue to move forward quickly, fast, with these investments, because our national security and defense depends on it.

I thank you, Mr. Chairman. I look forward to asking the witnesses more detailed questions about this, the President's budget, and why we need to make sure that we are funding this appropriate mission for the future, not just of our innovation, but also for our national security. Thank you.

Chairman CRUZ. I thank the Ranking Member. I would now like to introduce our witnesses for today. Each witness exemplifies essential elements of maintaining U.S. leadership in space.

Our first witness is Mr. Allen Cutler, President and Chief Executive Officer of the Coalition for Deep Space Exploration, a national organization comprising more than 50 space industry businesses and stakeholders, dedicated to ensuring that the U.S. remains the leader in space exploration.

Our second witness is Mr. Michael Gold, President of Civil and International Space for Redwire, where he leads a variety of commercial space activities. Prior to Redwire, he served as NASA's Associate Administrator for Space Policy and Partnerships, where he

directed the development and implementation of the Artemis Accords and the negotiations for the Lunar Gateway.

Our third witness is a good friend, the Honorable Jim Bridenstine, Managing Partner of the Artemis Group. He previously served as the 13th Administrator of NASA. Under Mr. Bridenstine's strong leadership, NASA launched the Artemis program to explore the Moon and to prepare for missions to Mars.

And our final witness is Lieutenant General John Shaw, the former Deputy Commander of the U.S. Space Command, where he was responsible for conducting operations in, from, and to space to deter conflict.

Mr. Cutler, you are recognized for 5 minutes.

**STATEMENT OF ALLEN CUTLER,
PRESIDENT AND CHIEF EXECUTIVE OFFICER,
THE COALITION FOR DEEP SPACE EXPLORATION**

Mr. CUTLER. Thank you. Chairman Cruz, Ranking Member Cantwell, members of the Committee, thank you for the invitation to testify today and for your consistent bipartisan support of NASA. That support has been critical to advancing our mission to return American astronauts to the Moon and building a sustained presence there. The most recent example of this support is the funding of NASA in the budget reconciliation bill that supports facilities and activities from Earth to Mars, including funds for the Artemis IV and Artemis V missions.

Artemis is more than a space program. It is the statement of American leadership to the rest of the world. It ensures that the United States, not our competitors or adversaries, sets the rules for lunar exploration and resource utilization. Without a successful Artemis program, we risk ceding the Moon to China, a nation working diligently to land before we return and looking to establish control over key lunar regions and resources. Their intent is clear, their progress is real, and time is not on our side. This is a race that the United States cannot afford to lose.

China's capabilities in space cannot be underestimated, whether in their activities orbiting Earth or its ambitious lunar program. China's persistence in achieving its national goals in space underscores its unfaltering intent to be the leader in space. Recent progress by China includes a successful static fire test of the Long March 10 rocket as well as successful early lunar lander tests to determine its capabilities.

The United States still retains advantages with the Space Launch System, Orion, Gateway development, and Exploration Ground Systems processing, but appears to trail China with a critical final leg in space to the Moon surface, the development of a lander.

Let me be very clear. The country that lands astronauts on the Moon next shapes the rules of engagement in space for decades to come.

The current Artemis program is making strong progress, but we need every element to execute its role. The technical challenges that need to be overcome to land on the lunar surface cannot be ignored, and Congress must keep a watchful eye on how that effort progresses if we are to win.

Artemis II is preparing for its crewed launch next year, but the work does not stop there. There is mission hardware being built today from Artemis III through Artemis IX. Factories are running, hardware is being manufactured, and thousands of Americans across the country are at work to make this campaign successful.

Additionally, the United States is leading a growing coalition of 56 partner nations that are the Artemis Accords, a global community initiated under President Trump's first term, focused on supporting a set of principles for peaceful, sustainable, and cooperative space exploration.

The rewards of advancing our lunar program extend beyond beating China. Artemis is an economic engine here at home. For every dollar invested in Artemis, three dollars flow back into our economy, supporting advanced manufacturing, creating high-quality jobs, and driving innovation that benefits Americans in their daily lives. Supporting Artemis to beat China creates stronger communities, a stronger industrial base, and a stronger America. This race is not just about the Moon. It is about economic growth, global competitiveness, and national security.

Congress can strengthen our national capabilities with a robust NASA authorization bill to reaffirm our commitment to the current plan and make improvements where necessary. It should continue the direction for lunar exploration found in the President's Space Policy Directive One, which calls for the United States to lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars. A multiyear authorization bill with these elements will provide the long-term certainty needed to keep NASA focused and our workforce, our partners, and our allies aligned.

Great strides are being made from lessons learned after the Artemis I mission, and even greater efficiencies and cost reductions could be realized, by cutting unnecessary requirements that are not safety critical, requiring a plan for a phased approach to commercial services for future Artemis missions to further drive down costs, and ensuring that decisionmaking at NASA centers and industry sites is available when the work is happening, increasing efficiency.

These steps will make Artemis more agile, more sustainable, while keeping the United States on track, but passing a bill on its own will not be sufficient. Congress must hold NASA accountable for implementing the laws Congress enacts.

Mr. Chairman and members of the Committee, the progress we have made is invaluable, the investments you have supported are paying off, the industrial base is ready and capable, and the Artemis generation is being inspired. If we lose momentum now, that progress will not be easily regained. But when successful, Artemis will deliver historic achievements that secure America's leadership for generations. With your continued support, Artemis will secure a place on the Moon before China, strengthen our economy here at home, and keep America strong.

Thank you for your time, your attention, and for your commitment to Artemis, NASA, and America's leadership in space.

[The prepared statement of Mr. Cutler follows.]

PREPARED STATEMENT OF ALLEN CUTLER, PRESIDENT AND CHIEF EXECUTIVE
OFFICER, COALITION FOR DEEP SPACE EXPLORATION

Chairman Cruz, Ranking Member Cantwell, and distinguished Members of the Committee. Thank you for the invitation to testify before the Committee, and for your consistent bipartisan support of NASA. That support has been critical to the progress we have made toward returning American astronauts to the Moon and building a sustained lunar presence. The most recent example is the funding for NASA in the reconciliation bill that supports facilities and activities from Earth to Mars, including funds for the Artemis IV and V missions.

The Coalition for Deep Space Exploration represents companies of all sizes across the United States, from small business suppliers to prime contractors that constitute the critical supply chain that enables our national space policy of leadership in space. For nearly a decade, this organization has been a resource and an advocate for industry as the country has embarked on the goal of returning to the Moon and eventually expanding our human exploration horizons onto Mars.

Artemis

Artemis is more than a space program. It is a statement of American leadership to the rest of the world. It ensures that the United States, and not our competitors and adversaries, sets the rules for lunar exploration, resource utilization, and governance.

Without a successful Artemis program, we risk ceding the Moon to China, a nation working diligently to land before we return and establish control over key lunar regions and resources.

Their intent is clear. Their progress is real. And time is not on our side. This is a race the United States cannot afford to lose.

China

China's capabilities in space cannot be underestimated, whether in their activities orbiting Earth or their ambitious lunar program. For example, the Long March rocket is so named to signal China's persistence in achieving its national goals in space and underscores its unfaltering intent to be the new world leader in space.

Recent tests of their lunar infrastructure demonstrate the systematic process they are following to accomplish a crewed landing on the Moon. In June, China conducted a test of its crew vehicle launch abort system. In August, the Long March 10 rocket successfully conducted a static test fire, paving the way for a test launch, and China also conducted a simulated takeoff and landing of its two-person lunar lander.¹ These are the hallmarks of a space program that is progressing towards its goals.

The United States currently holds advantages with the Space Launch System (SLS), Orion, Gateway development, Exploration Ground Systems processing, and other essential elements of the Artemis architecture. Our launch and crew vehicles have successfully flown an uncrewed test mission to the Moon and are poised to fly again with astronauts on board next year. China, on the other hand, is making steady, notable progress with its Lanyue lander, already testing its design for capabilities needed to land on the lunar surface.

Current Status of Artemis

To be very clear: the country that lands on the Moon first will shape the rules of engagement in space for decades to come. That leadership must come from the United States.

The Artemis program has received strong bipartisan support across Administrations and Congresses, and it is already delivering results. Artemis II is preparing for its crewed launch next year, but the work does not stop there. There is hardware being built today for Artemis III and continuing all the way through Artemis IX. Factories are running, hardware is being manufactured, and thousands of Americans in every state are at work to make this campaign successful.

The opportunity to win the race is there, but we need every element to execute to prevent China from landing the next astronauts on the Moon. The current Artemis architecture is making strong progress, but the technical challenges that remain to be overcome to land on the surface cannot be ignored. Congress must keep a watchful eye on how that effort progresses if we are to win.

Additionally, the United States is leading a coalition of 56 partner nations, and growing, under the Artemis Accords. A global community, initiated under President

¹ <https://www.space.com/astronomy/moon/china-is-making-serious-progress-in-its-goal-to-land-astronauts-on-the-moon-by-2030>

Trump's first term, supporting a set of principles for peaceful, sustainable, and cooperative civil space exploration from the Moon to Mars and beyond.

Every tool at the country's disposal must come to bear if we are to be successful. However, we need those tools to be available. The proposed Fiscal Year 2026 budget, with its vision of cancelling programs, has caused companies to question whether their role in supplying Artemis will continue. Industry wants a stable and predictable environment so that planning and investments can be maximized. However, the uncertainty injected into the Artemis program about its future has upended those plans. These actions are particularly destructive to the smaller companies that NASA and its partners rely on for their missions and could put them in financial jeopardy. Proactive actions limiting work on Artemis ahead of Congressional action are crippling our capability to produce the hardware needed for missions for Artemis IV and beyond. Turning off the existing means for continuing our lunar program when no replacement exists will not position us to beat China.

The Economic Return of Artemis

The rewards of advancing our lunar program extend beyond beating China. Artemis is an economic engine here at home. For every dollar invested, three dollars flow back into our economy, supporting advanced manufacturing, creating high-quality jobs, and driving innovation that benefits Americans in their daily lives. In the most recent NASA Economic Impact Report, NASA's Moon to Mars activities generated more than \$23.8 billion in total economic output and supported an estimated 96,479 jobs nationwide, stemming directly from \$7.7 billion in Moon to Mars program spending.²

Supporting Artemis to beat China creates stronger communities, a stronger industrial base, and a stronger America. This race is not just about the Moon, it is about economic growth, global competitiveness, and national security.

NASA's history shows that space exploration is inseparable from national security, as demonstrated by Apollo's technological advances, workforce development, and its symbolic power in uniting the Nation and projecting U.S. leadership. Today, with renewed competition from China, the same principle holds: government must lead when missions are high-risk, capital-intensive, and at low technology readiness levels. Commercial services become viable only after the government has de-risked the fundamentals by ensuring infrastructure, standards, and industrial base continuity. For Moon and Mars exploration, government leadership is not anti-commercial but pro-market, retiring risks that open the doors to industry. It has happened time and again across industrial sectors and is occurring today in the space sector.

NASA Authorization

Congress can strengthen our national capabilities with a strong NASA authorization bill. That bill should reaffirm our commitment to the current plan, with improvements as necessary. It should continue the direction for lunar exploration found in the President's Space Policy Directive-1, which calls for the United States to lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars.

To underscore our commitment to exploring the Moon and the need for stability in the Artemis program by maintaining a regular mission launch cadence, Section 10812 of the CHIPS and Science Act (Public Law 117-167), included the following provision:

“After the first crewed lunar landing of the Administration's Moon to Mars activities, the Administrator shall, to the extent practicable, seek to carry out a flight rate of 2 integrated Space Launch System and Orion crew vehicle missions annually until the lunar activities needed to enable a human mission to Mars are completed so as to maintain the critical human spaceflight production and operations skills necessary for the safety of human spaceflight activities in deep space.”³

Current law recognizes that the current architecture and a regular flight cadence are the path from our exploration of the Moon to exploring Mars. NASA's plan as part of the Fiscal Year 2025 budget included annual launches of SLS and Orion after Artemis IV. It highlights that the stability a regular mission cadence creates also benefits our space industry. Injecting uncertainty at this juncture invites unnecessary concern and distracts NASA and its partners from what they should be focused on: a successful Artemis campaign.

² <https://www.nasa.gov/wp-content/uploads/2024/10/final-fy23-nasa-economic-impact-report.pdf>

³ <https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf>

A new multi-year authorization bill will provide the additional certainty needed to keep NASA focused and our workforce, our partners, and our allies aligned.

Great strides are being made from lessons learned after Artemis I. NASA could realize even greater efficiencies and cost reductions by:

- Cutting unnecessary requirements that are not safety critical. With the success of the Artemis I mission, both NASA and industry have found ways to do the same activities in an efficient manner that cuts time and reduces cost. This is being done within the confines of the current contracts. A provision allowing even greater flexibility to cut red tape will enable benefits to cost and schedule to become even greater.
- Requiring a study of a phased approach to commercial services for future missions to further drive down costs. It should direct NASA to map out a phased approach to transition to a fixed price model for the Artemis program, including potential services contract approaches.
- Ensuring that decision-making at NASA centers and industry sites is available when the work is happening, increasing efficiency. To meet production schedules, NASA's industry partners may need to run operations outside the traditional Monday-Friday 9 to 5, yet work can grind to a halt when a decision needs to be made outside regular business hours. Delays of a day or hours add up over time and contribute to needless loss of schedule margin. If NASA and industry are working together on a unified goal, they should be able to count on each other to be there when it counts.

These steps will make Artemis more agile, more efficient, and more sustainable, while keeping the United States on track to lead in deep space exploration. But passing a bill on its own will not be sufficient; Congress must hold NASA accountable for implementing current law and adhering to the direction in any legislation signed into law.

Conclusion

The progress we have made is invaluable. The investments you have supported are paying off. The industrial base is ready and capable. The international partnerships are real and growing in number. And the next generation, the Artemis generation, is being inspired.

If we lose momentum now, that progress will not be easily regained. But when successful, Artemis will deliver historic achievements that secure America's leadership for generations.

We must not falter.

With your continued support, Artemis will secure our place on the Moon before China, strengthen our economy here at home, and keep America strong.

Thank you for your time, your attention, and for your commitment to Artemis, NASA, and America's leadership in space. The Coalition for Deep Space Exploration looks forward to working together with the Committee on a bipartisan basis to ensure we are successful in thwarting China and showing what true leaders in space can accomplish.

Chairman CRUZ. Thank you. Mr. Gold, you are recognized.

STATEMENT OF MICHAEL GOLD, PRESIDENT, CIVIL AND INTERNATIONAL SPACE, REDWIRE

Mr. GOLD. Thank you Chairman Cruz, Ranking Member Cantwell, and distinguished members of this Committee. I am grateful to all of you, as well as your intrepid staff, for the opportunity to testify. But I am even more grateful for the work this Committee has done to support American leadership in space via the One Big Beautiful Bill Act.

Also, I would be remiss if I didn't thank Senator Cruz, in particular, for your leadership. Senator Cruz and I both share a strong affinity for Star Trek, and the highest compliment I can pay the Chairman is that he is the Captain Kirk of the Senate. Thank you, Senator.

Chairman CRUZ. Your time is extended to 10 minutes.

[Laughter.]

VOICE. Mr. Chairman, I think that could be a new nickname in the Senate here.

Chairman CRUZ. Well said, Mr. Spock.

[Laughter.]

Mr. GOLD. Well, with your leadership we'll live long and prosper. And I am so grateful that while others sat down, Senator Cruz, Senator Cantwell, and all of you have chosen to stand up and to fight for this Nation's future in space. Specifically, for the direction of the One Big Beautiful Bill, NASA must complete and launch the Lunar Gateway. Just last month, along with NASA officials and representatives from all of our international partners, I watched the successful deployment test of Redwire's massive rollout solar arrays for the Gateway's power and propulsion element. These arrays, which will be some of the largest ever deployed by humanity in space, will power the Gateway, representing the pinnacle of solar electric propulsion technology, a key capability for both future civil space exploration and national security exhibits. Without the funding and direction of the One Big Beautiful Bill, this critical work would be in jeopardy. I am sure China would like nothing more than for the U.S. to abandon its lead in solar electric propulsion and to lose the benefits of Gateway in orbit and on the lunar surface.

With Gateway and full commercial logistics services, the Artemis program can support lunar surface operations for 60 to 90 days, enabling robust activities and transforming the dream of lunar resource extraction and utilization into reality. Without Gateway, lunar surface activities will be limited to 5 to 7 days, dramatically curtailing the very nature of NASA operations.

Additionally, while not a military facility, the presence of Gateway in cislunar space will provide a platform that will inherently allow America and its partners to monitor Chinese activities. A permanent spacecraft orbiting the Moon will project American influence and power forward, discouraging illicit Chinese operations that may otherwise occur in the shadows.

Moreover, Gateway is critical for projecting American power not only in space but here on Earth. Over 60 percent of the Gateway's costs are being borne by our international partners, representing billions that have already been spent building hardware. Turning away from Gateway now would squander this unprecedented global investment in Artemis and force our international allies to seek partnerships with America's geopolitical rivals.

Conversely, if NASA reaffirms its commitment to Gateway, we can unlock billions of dollars of additional international investments, creating even more robust capabilities for Artemis, along with a windfall for the American taxpayer. The combined Gateway PPE and HALO modules can be completed and launched in 2027, a mere two years from now. We could achieve an early win in this competition if America can simply demonstrate that wherewithal not to give up on the race when we are so close to the finish line.

Additionally, the success of our lunar and Martian exploration efforts depend upon maintaining a strong foundation in low Earth orbit. The technologies, experience, and partnerships that occur in LEO drives the capabilities of our entire space enterprise. For example, at Redwire, using our biofabrication facility on the Inter-

national Space Station, we have printed the first-ever human meniscus in space. Who doesn't need a meniscus? We followed this up with printing live cardiovascular tissue, and bringing it back, still live. Eventually we could print whole organs in space. That would save countless lives.

We are also, at Redwire, making even more progress in drug development, with our Pillbox system, which has now flown 32 times on the International Space Station. We have demonstrated how larger and more uniformed sea crystals, things we've grown in space, leading to the development of advanced pharmaceuticals with better efficacy, longevity, and fewer side effects.

There is no question in my mind that microgravity manufacturing will transform the pharmaceutical and biotech fields. The only question is will those benefits be enjoyed in China or here in the United States?

Without the funding of the One Big Beautiful Bill Act, and explicit action by NASA within the next few months, we run the risk of reducing the number of American astronauts on the ISS from 4 to 3, and then down to 2. If this Committee's directives are not followed, for the first time in history there will be more Chinese astronauts in space than Americans. This should be unacceptable—unacceptable to Congress, unacceptable to NASA, and unacceptable to this Nation.

Again, I'm grateful to this Committee for the support of Artemis, the ISS, and NASA science. Together we must speak out with one unified voice that we will not cede LEO, our international partnerships, and the Moon to the tender mercies of the Chinese Communist Party. I urge us, all of us here today and listening online, to fight—fight for the ISS, fight for Artemis, and fight for America's future in space.

[The prepared statement of Mr. Gold follows:]

PREPARED STATEMENT OF MICHAEL GOLD, PRESIDENT,
CIVIL AND INTERNATIONAL SPACE, REDWIRE

I. INTRODUCTION

Chairman Cruz, Ranking Member Cantwell, and distinguished Members of the Committee, I'm grateful to all of you as well as your intrepid staff for the opportunity to testify regarding America's existential struggle with China in the final frontier. Not only do I want to thank you for bringing attention to this critical competition, but I would be remiss if I did not thank Chairman Cruz in particular for his unflagging and singular leadership on behalf of the American space enterprise generally, and most recently, for restoring vital NASA funding for

human spaceflight within the One Big Beautiful Bill Act (OBBBA). Senator Cruz and I share a strong affinity for Star Trek, and the highest compliment I can pay the Senator is that he is the Captain Kirk of the Senate. Additionally, like in Star Trek, a good Captain depends upon their crew, and the work of Maddy Davis, Duncan Rankin, and the entire Commerce Committee staff on both sides of the aisle deserve high praise.

Per the title of this hearing, Congress has been an invaluable partner to NASA in its efforts to thwart Chinese domination of space, and the stakes have never been higher. Space represents the ultimate high ground. Dominance in space brings with it incalculable scientific, economic, geopolitical, and national security benefits. I am confident that the Nation that controls the Moon will ultimately control the Earth, and we stand on the precipice of ceding that control to the Chinese Communist Party. If NASA fails to implement the vital space-related provisions of the OBBBA with alacrity, we will not only fail to beat China back to the Moon, but will suffer dramatic consequences here on Earth. Of the many critical provisions of the

OBBBA, among the most important is America upholding its commitment to the Lunar Gateway.

II. GATEWAY: PROJECTING AMERICAN POWER IN CISLUNAR SPACE AND ON EARTH

Before looking forward we must look to the past. Specifically, when it comes to beyond low Earth orbit (LEO) human spaceflight, America has failed to sustain a program since Apollo. For beyond LEO, failure hasn't just been an option, it has been a certainty. No beyond LEO human spaceflight program has made the leap from one partisan administration to another until, for the very first time, Artemis successfully navigated this transition from its birth in the first Trump administration, to the Biden administration, and now back to President Trump's second term. Successful space development requires years if not decades of continuity, which is why the unprecedented bipartisan success of the Artemis program must be maintained.

Moreover, much of the Gateway's hardware has already been built. For example, at Redwire, we are proud to have evolved the innovative Roll Out Solar Array (ROSA) technology, which was initially developed for and is currently being used on the International Space Station (ISS), to build even larger versions of these already enormous arrays for the Gateway's Power and Propulsion Element (PPE). This summer, with the support of our customer, Maxar, we conducted deployment tests of these arrays which unfurled like futuristic sails, filling an enormous high bay building at Redwire's ROSA manufacturing facility. Similarly, our colleagues at Northrop Grumman are in the process of outfitting the Habitation and Logistics Outpost (HALO) module which will be united with the PPE and launched together on a SpaceX Falcon Heavy rocket to lunar orbit. This could be done by the summer of 2027, a mere two years from now, if America can simply demonstrate the where-withal not to give up on the race when we are so close to crossing the finish line.

Terminating Gateway would result in a horrific waste of time, money, and effort. Conversely, if we follow the law, and continue with Gateway per the explicit direction of the OBBB, then the U.S. can become the first nation to deploy a crewed outpost around the Moon, achieving a trailblazing victory for NASA, the administration, Congress, and the American people. The alternative is to squander years of funding, hardware, and effort, while willingly ceding the initiative and control of the Moon to the tender mercies of the Chinese Communist Party. The right choice is abundantly clear, but can only be achieved if NASA abides by its legal obligations under the OBBBA.

Continuing with Gateway also provides extraordinary benefits here on Earth. Over 60 percent of the Gateway's costs are being born by NASA's international partners, specifically, the European Space Agency, and the governments of Japan, Canada, and the United Arab Emirates. President Trump has wisely pushed our NATO allies to fund their fair share of defense contributions. Here we have an example of our international partners doing the right thing, providing robust funding to support American leadership yet, despite the crystal clear and explicit directives of the OBBBA, and even supportive language from the White House complimenting the space provisions of the Bill, NASA is still unable to explicitly reassure our international partners that Gateway will continue.

NASA's waffling on Gateway has left our international partners confused, frustrated, and exploring alternatives to American partnerships. If we fail to continue with Gateway, we will force our partners to consider shifting support from Artemis and America, to China and its International Lunar Research Station (ILRS) program. Unlike the U.S., China has maintained strong and consistent continuity for its lunar beyond LEO spaceflight program, making a collaboration with China potentially far less risky than gambling on what, prior to Artemis, has been a mercurial American beyond LEO space strategy. If our international partners make such a shift to China, it will not only impact the space field but will have substantial diplomatic, geopolitical, and economic consequences on Earth.

Conversely, by honoring our commitment to Gateway, and following the direction of the OBBB, we can gain access to continued investments by our international partners to support Artemis and American leadership. The international partners have invested roughly billions of dollars in Artemis thus far, and will likely be willing to invest billions more throughout the lifetime of the Artemis program. These investments by the international partners represents a windfall to the American taxpayer, supporting robust U.S. leadership on the Moon and Mars at no cost. The alternative is for these international partners and funds to be funneled into China's ILRS program. Again, the decision to continue with Gateway should be simple and clear.

Additionally, while not a military facility, the presence of Gateway in cislunar space will provide a platform that will inherently allow America and its partners to monitor Chinese activities. A permanent spacecraft, orbiting the Moon, will project American influence and power forward, discouraging illegal and illicit operations by rival nations that may otherwise occur in the shadows.

Gateway also represents an excellent opportunity for the private sector and for NASA to further leverage public-private partnerships. Specifically, the PPE and HALO will be deployed by a commercial vehicle, Gateway logistics will be carried out via commercial contracts similar to the extraordinarily successful commercial re-supply services agreements that have worked so well in LEO. Also, Gateway can serve as a hub for commercial logistics, bolstering the private sector's ability to execute lunar missions generally and extraterrestrial resource extraction in particular.

Gateway is the key to enabling vital innovative activities such as in-situ resource utilization (ISRU) and to ensure that America can successfully access the Moon's resources. With Gateway and full logistics services, American astronauts could remain on the lunar surface for 60–90 days. Without Gateway, American astronaut time on the lunar surface drops precipitously to a mere 5–7 days. In addition to enabling dramatically more robust lunar surface activities, the Gateway provides a safe haven for astronauts, substantially enhancing the safety of lunar operations and ultimately saving lives.

Gateway, and the PPE in particular, will also help ensure American technological leadership over China. Gateway's PPE, powered by the aforementioned innovative Redwire ROSAs, and developed in a collaboration between Maxar and NASA Glenn Research Center, will represent the pinnacle of solar electric propulsion (SEP) technology. Mastering SEP is a critical capability for both civil space exploration and national security space operations. Again, it would be tragic to waste hardware such as the PPE ROSAs which are already constructed and currently undergoing testing and qualification. While bad for America, such a regressive decision would certainly be applauded by China since it clears its competitor as well as a critical rival technological capability from their path to the Moon.

Gateway's benefits even extend beyond the Moon creating advantages for future missions to Mars. Gateway will serve as a critical testbed for Martian operations by providing NASA with vital experience operating an orbiting spacecraft in support of surface activities. The Apollo missions were short duration sojourns into cislunar space. America was dipping its toe into a vast ocean. With the long duration operations enabled by Gateway, we can learn to swim in the ocean of deep space through the use of this permanent lunar outpost.

For all of these reasons, I thank the Members of this Committee for their support of Gateway, and urge the Committee to ensure that NASA immediately reaffirms its commitment to Gateway via explicit communications to both domestic commercial and international partners.

III. THE IMPORTANCE OF BEING FIRST

As the old saying in sports goes, if you're not first, you're last, and that is certainly the case when it comes to the Moon. The first nation to return to the Moon will enjoy tremendous technological, geopolitical, and military benefits. Additionally, there is so much more to be discovered on the Moon. Until 2009, we believed the Moon was bone dry. Today, we now know that there are vast amounts of frozen water ice, a resource that will support robust development and allow the Moon to become a fuel depot for missions to Mars and even more ambitious journeys of discovery throughout the solar system. If America isn't the first to return to the Moon, we risk ceding the best ice reserves to China, losing the ability to effectively create not only drinkable water, but air and rocket fuel. Additionally, by falling behind, we also risk leadership in the extraction and utilization of Helium-3, which already has great economic potential and, in the future, could support a clean and abundant power revolution. Worst of all, by ceding leadership on the Moon to China, we not only miss out on the opportunities that we understand today, but all of the unknown resources that are sure to be the discoveries of tomorrow.

The Space Launch System and Orion capsule represent the best and only practical means of beating China to the Moon before 2030. Therefore, per the provisions of the OBBBA, we must continue to leverage these systems to both win the space race with China and maintain an American presence in lunar orbit and on the lunar surface. At the same time, we're fortunate that companies such as Blue Origin and SpaceX are developing human landing systems that represent a key commercial contribution to the Artemis architecture. These systems will provide affordable, sustainable, and robust lunar and even Martian capabilities. Fielding multiple spacecraft, or at least two alternatives, for lunar transportation will be vital to win the

space race with China. Two or more lunar transportation systems will avoid dependence on any single spacecraft or company. This will enhance safety while also ensuring healthy competition that will encourage efficiency, affordability, and innovation.

Moreover, the first country to return to and develop the Moon will ultimately write the rules of the road. The Artemis Accords, developed and implemented during the first Trump administration, have represented a historically unprecedented victory for American space policy. 56 countries have now signed the Artemis Accords, in contrast to the 13 that have signed China's ILRS agreements. America must lead not just in technology, but in policy, and the Accords have accomplished this goal. However, if China lands on the Moon before America, those numbers will likely shift in China's favor, and the actions that China takes on the Moon will set broad and varied precedents that will be extremely difficult to overcome.

For all of these reasons, we must be first. Someone who has an innate understanding of this challenge is NASA Interim Administrator and Secretary of Transportation Sean Duffy who, in his short time at NASA, has shown strong leadership, vision, and summarized the situation quite well by saying "Beijing wants to land on the Moon before 2030. The clock is ticking . . . but NASA is up to challenge. I have full confidence in our ability to get there FIRST."¹

We cannot afford to lose the space race to China on the Moon or Mars, and winning will require an 'all of the above' strategy. We must come together as a united space community. Only by fighting for our future, instead of fighting each other, can we prevent a bad moon from rising.

IV. LIVING OFF OF THE LAND THROUGH COMMERCIAL PARTNERSHIPS

China will eventually outspend the U.S. government in space. Such a scenario may be inevitable. Therefore, America must out-entrepreneur the Chinese. NASA should continue to leverage public-private partnerships to the greatest extent possible. An excellent example of this is NASA's Commercial Lunar Payloads Services (CLPS) program. CLPS has been able to take a modest government investment and substantially bolster it with robust private sector funding. A whole new ecosystem of lunar development and lunar entrepreneurship has been created by the CLPS program. NASA should be commended for its continued commitment to CLPS, and the further development of this innovative initiative via CLPS 2.0 and its initial work to extend the CLPS paradigm to Mars.

Additionally, for several CLPS and even some non-CLPS companies, during the first Trump administration, NASA executed a historic series of agreements to purchase lunar regolith from commercial providers. This practice, of purchasing resources from lunar exploration companies, should no longer be the exception but should become the rule. Specifically, this innovative practice should be implemented with every CLPS mission, to encourage the continuous growth of ISRU capabilities and resource extraction technologies.

At Redwire, we're building innovative technologies in collaboration with NASA to transform lunar regolith into useful structures. Specifically, via the 'Mason' program we are developing a system that uses microwaves to sinter regolith. The potential first application for Mason is to create flat landing pads to support safe and successful spacecraft landings. This technology, which can be carried and utilized by a variety of mobile systems, can not only be used to create landing pads, but also roads, berms, and even habitats. Mason is part of the NASA Space Technology Mission Directorate's Tipping Point program, and is an example of the kind of public-private partnership that the agency should do more of, ideally via the use of Broad Agency Announcements and simple single-page initial applications, reflecting best practices used by DARPA.

In summary, America's success in the race against China on the Moon will unquestionably be determined by which country can most effectively learn to live off of the land, hence the need to continue and expand NASA's innovative lunar resource purchases and public-private partnerships.

V. THE IMPORTANCE OF LEO

In any foot race, it can be won or lost by how an athlete jumps off the starter's block, and the race to the Moon begins in LEO. The technologies, capabilities, partnerships, and business cases that are developed and implemented in LEO will have a substantial influence on the overall efficacy of any nation's space program. Therefore, the importance of NASA's continued success in LEO cannot be separated from its future success on the Moon and Mars. Fortunately, the OBBBA provides support

¹<https://x.com/SecDuffyNASA/status/1961129995364876486>.

for LEO operations. Under the OBBBA, NASA will maintain four astronauts on the ISS, enabling the station to remain a critical testbed for Artemis activities and an engine for innovation and job creation.

At Redwire we are leveraging the ISS to conduct a wide variety of trailblazing microgravity work. For example, using our BioFabrication Facility (BFF), we printed the first meniscus in space. Subsequently, based on our experience with the meniscus fabrication, we printed live cardiovascular tissue on the ISS, and returned it to Earth while the tissue was still alive. Additionally, the most recent cargo resupply mission to the ISS, which launched last month, included provisions for Redwire to conduct a liver tissue print with the BFF. Due to the lack of gravity aboard the ISS, biological tissues can be manipulated and used to fabricate increasingly complex organic structures. Our goal at Redwire is to eventually print whole organs in space, and the work that is being done now by the BFF is bringing that future closer to reality. Imagine a world where there is no organ donor list, and instead those in need can quickly receive an organ that was grown for them. Not only would such a capability save an untold number of lives in America and around the world, but since the organs could be grown from a patient's own stem cells, they would be able to avoid expensive and painful anti-rejection therapies.

While organ fabrication remains a potential, albeit increasingly likely, capability, the future is now for the pharmaceutical industry. Specifically, Redwire has already flown 32 Pharmaceutical In-Space Laboratory (PIL) Boxes on the ISS which have tested 17 different compounds. These PIL Box missions have demonstrated that, under microgravity conditions, drug seed crystals can be created in space which are larger and more uniform than terrestrially grown crystals. These improved seed crystals can subsequently be used to create drugs with better efficacy, longevity, and fewer side effects. New drugs can be introduced and existing drugs can be improved. For example, due to knowledge gained from microgravity research and development, Merck has been able to create an improved version of a cancer treatment called Keytruda. The newly formulated version of Keytruda will potentially allow patients to avoid lengthy, painful, and expensive chemotherapy at hospitals or clinics, and instead enjoy the ease and affordability of taking a shot home for injection. Redwire's PIL-BOX experiments have shown example after example of the power of microgravity to create differentiated seed crystal results. After a collaboration with Eli Lilly flying insulin, Redwire was told by the company that we created the "prettiest seed crystals they have ever seen".

Due to the success and maturity of these efforts, last month Redwire signed a trailblazing agreement with the pharmaceutical company ExesaLibero. Under this agreement, Redwire will receive a percentage of sales from a pharmaceutical for osteoporosis that ExesaLibero will develop in space. To the best of my knowledge, this is the first time that an agreement unites the potential revenue from the pharmaceutical industry with the capabilities of a space company. This agreement therefore represents an inflection point, with space and pharma/biotech coming together in a manner that will transform both fields. Redwire has even formed a new subsidiary entity called 'SpaceMD' to explicitly focus on the creation of new and/or improved drugs in space, and feeding those drugs into the pharmaceutical industrial development chain.

However, at a time when we are just now beginning to realize the incredible potential of microgravity for pharmaceutical development and a wide variety of other fields, the ISS is facing budget cuts that could cripple its vital operations. Specifically, without the funding provided by the OBBB, the number of American astronauts in LEO will drop from four to three and eventually to only two. Falling to three and then two astronauts will dramatically impact America's ability to support innovative commercial activities, as well as damaging the critical industrial base created by the commercial cargo and crew programs. Moreover, for the first time in history, China will have more astronauts in space than America. Such a situation should be unacceptable to this Committee, NASA, and the Nation as a whole. Again, I applaud this Committee for fighting for American leadership in space and restoring ISS funding to a level that will allow the U.S. to continue with four astronaut in LEO. Unfortunately, while this direction from Congress is commendable, I fear that more vigilance and action by this Committee will be required. Specifically, NASA will have to purchase a new cargo resupply mission within, at most, the next 90 days. If NASA does not take this action America will lose the ability next year to support four astronauts on the ISS, putting China in parity with the U.S. astronaut program for the first time in history.

I believe dropping the number of U.S. astronauts and failing to take advantage of the innovations created by the commercial crew program would be both ill-conceived and unwarranted. As described previously, we are on the precipice of incredible breakthroughs in microgravity that could transform not only the pharma-

ceutical and biotech industries, but numerous other diverse fields ranging from semiconductor production to next-generation agriculture. There is no question in my mind that microgravity R&D and manufacturing will provide transformative industrial benefits. The only question is, will those benefits be enjoyed here in the U.S. or in China.

VI. CONCLUSION

Again, the space race with China is one that cannot be lost. It doesn't matter that we reached the Moon in the 1960s any more than a victory by a sports team from over sixty years ago is relevant for this season's performance. Space is the ultimate high ground, providing an environment with untold strategic advantages, as well as technological, geopolitical, and economic benefits. The countries that master microgravity and develop the Moon will shape humanity's future. When we go to space, we launch not just our spacecraft and astronauts but our values, and we must re-dedicate ourselves to ensuring that the future reflects American values rather than those of an autocracy hostile to human rights and the very nature of democracy. However, due to the courage, leadership, and vision shown by the Members of this Committee and its staff, I remain confident that while our journey will be to LEO, the Moon, and Mars, that our ultimate destination will be freedom, peace, and prosperity.

Chairman CRUZ. Thank you, Mr. Gold. Mr. Bridenstine.

STATEMENT OF HON. JIM BRIDENSTINE, MANAGING PARTNER, ARTEMIS GROUP, AND FORMER ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BRIDENSTINE. Thank you, Chairman Cruz, Ranking Member Cantwell, and members of the Committee. It is an honor to be here.

After hearing Mike Gold's testimony, I want to comment on a few things in my 5 minutes. Number one, everything he said about medicine and microgravity is correct. We are seeing transformational capabilities in pharmaceuticals because atoms and molecules organize differently in microgravity than they do here on Earth. There are drugs that we are demonstrating on the International Space Station that we can create that can do things like, you know, we had a drug, a Merck drug, Keytruda, which is for lung cancer, and we were able to make that drug so that instead of trying to find out within 2 or 3 months if it is going to be efficacious, you can find out within 2 to 3 weeks whether or not it is going to be efficacious. Instead of administering it with an infusion, which takes time and is painful and is costly, you can do it with a pill. And that is just one drug that is improved. We are talking about drugs to treat diseases that have never been treatable before.

To piggyback on what Mike Gold just said, we are either going to have that capability in the United States because we have a permanent human presence in space with a fully mission-capable space station, or we're going to cede that to China. It is really that simple.

Now, that's just on the pharmaceutical side. Then we also talk about regenerative medicine, where we are actually 3D printing tissue. Mike mentioned the meniscus, where we are growing, in 3D, tissue like cardiovascular tissue and vein tissue, and other things. This type of regenerative medicine is critical to the future economy of the United States of America, and if we want to not have a fully mission-capable system, if we want to not have a permanent human presence in space, then not only does that capability go to China but all of our international partners go to China, as well, because they want that capability. This is a big deal.

So that's on the low Earth orbit side of things. And Senator Cruz, I know you are getting a lot of accolades today, but it is absolutely true. The One Big Beautiful Bill with the \$10 billion additional dollars for NASA human space flight was, in large part, your doing, and I know it was bipartisan. I know the One Big Beautiful Bill might not have been bipartisan, but that element was, in fact, bipartisan, and I know Senators on both sides of the aisle are grateful for your leadership on that. So very important.

I would also say the purpose of this hearing is, you know, are we going to be able to get to the Moon first. I mean, that's the title of the hearing. And I will tell you, and I know there are going to be questions, and I will go into more depth later, but look at the architecture that we have developed to land American astronauts on the Moon. Look at the architecture. It is extraordinarily complex. In some cases, you know, it hinges on me saying here today that it is highly unlikely that we will land on the Moon before China. And I am going to explain it in the next 2 minutes.

Number one, we have the SLS rocket, which is the most powerful rocket ever built, and Senator Cruz mentioned, yes, it has had its problems in the past. It has been expensive. It had overruns, all those things. But it is behind us, it is done, and we need to use it.

We have the Orion Crew Capsule, which, quite frankly, is a shiny object in this whole thing. The Orion Crew Capsule is not only usable today, but ultimately the cost is going down because more and more of it is reusable every time we use the Orion Crew Capsule. Those two elements are in good shape.

I will tell you, I have been critical of both in the past, in front of this Committee and other places, and I am more than happy to be critical of all of our contractors, just to be really clear. But I will say what we don't have today—here's what we don't have today—we don't have a landing system for the Moon. And there was a moment in time when we had no NASA Administrator. It was after I was gone and before Senator Nelson became the NASA Administrator, and architecture was selected. And I don't know how this happened, but the biggest decision in the history of NASA, at least since I have been paying attention, the biggest decision happened in the absence of a NASA Administrator, and that decision was instead of buying a Moon lander, we are going to buy a big rocket. And I want to be clear—we need this rocket to be successful. It is important for the country and it is transformational. But in the meantime, the architecture is as such.

We need to launch Starship. That first Starship is a fueling depot that is in orbit around the Earth. Then we need to launch, nobody really knows, nobody knows, but it could be up to dozens of additional Starships to refuel the first Starship. So imagine launching Starship over and over and over and over and over and over and over, dozens of times, no delays, no explosions, to refuel the first Starship. Then, once it is fully refueled, then that Starship has to fuel another Starship that is, in fact, human rated, which that process has not even started yet.

By the way, that whole in-space refueling thing has never been tested either. We are talking about cryogenic liquid oxygen, cryogenic liquid methane, being transferred in space. Never been done

before. And we are going to do it dozens of times. And then we are going to have a human-rated Starship that is refueled, that goes all the way to the Moon.

Now, when it goes to the Moon, we do not know how long it can be there because it is boiling off the entire time it is in orbit around the Moon, so we don't know how long it can be there. But while it is there, we have to launch the SLS. We have to launch the Orion, the European Service Module. We have to have astronauts and crew all ready to go. And they have to orbit the Moon themselves, in that window, that window when Starship is around the Moon, and then they have to dock around the Moon. They have to transfer from the Orion into the Starship. It has to go down and land. When it is on the surface of the Moon, Orion is gone for the next 7 days, until it comes back around in near-rectilinear HALO orbit.

So our astronauts are right now planning to be on the surface of the Moon for a period of 7 days without any way home. This is an architecture that no NASA Administrator, that I am aware of, would have selected had they had the choice. But it was a decision that was made in the absence of a NASA Administrator in the last Administration. It is a problem, it needs to be solved, and that puts us, as a nation, at risk of not being the first on the Moon—I should say the first next on the Moon, because we did land, in 1969 to 1972.

And Chairman Cruz, I would like to compliment you. I have heard that you have said that we need to put it into law that the Wrath of Khan is, in fact, the greatest Star Trek movie in history, and we are in agreement with that.

So with that I yield back the time that I took from the General.
[The prepared statement of Mr. Bridenstine follows:]

PREPARED STATEMENT OF HON. JAMES F. BRIDENSTINE, MANAGING PARTNER, ARTEMIS GROUP AND FORMER ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Chairman Cruz, Ranking Member Cantwell, members of the Senate Committee on Commerce, Science, and Transportation, thank you for the opportunity to testify before you today at a pivotal time in the history of our Nation.

We spent the latter part of the 20th Century in a great power struggle with the Soviet Union. Thanks in part to the space program, we came out on top and spent the last 30 years as the world's sole superpower. However, we once again find ourselves in a great power struggle, this time with China.

I truly believe that this Administration and this Congress, on both sides of the aisle, share a common goal of promoting American leadership in space. NASA can only succeed when we look across multiple presidential administrations, span many Congresses, and carry out programs through ebbs and flows of public support. NASA Authorizations are key tools that provide the continuity necessary to accomplish big things, so I am very grateful you are holding this hearing.

The Artemis Program

SLS, Orion, and Landing on the Moon

We are mere months away from sending humans to the Moon for the first time in over 50 years. Let me repeat that: in early 2026, we will send American astronauts to orbit the Moon. No other nation has been able to accomplish this. This is a monumental moment for the United States. Our leaders should be trumpeting this from the roof tops.

Those astronauts will go to moon on top of the Space Launch System (SLS), inside of the Orion Multi-Purpose Crew Vehicle. These vehicles represent the only human rated super heavy lift rocket and the only human rated capsule currently capable of taking astronauts to deep space. While the development of these programs has

been too expensive, we are starting to see the fruits of those efforts come to bear. The One Big Beautiful Bill Act, signed by the President, which members of this Committee advanced, recognizes the importance of these systems and continues them through Artemis IV and V. However, it should be noted that the cost and throughput of SLS is not sustainable without significant changes.

While the United States should celebrate orbiting the Moon in 2026, the United States does not have a lander. Unless something changes, it is highly unlikely the United States will beat China's projected timeline to the Moon's surface. Our complicated architecture requires a dozen or more launches in a short time frame, relies on very challenging technologies that have yet to be developed like cryogenic in-space refueling, and still needs to be human rated. While the capability could be transformational over time if payload capacity increases (so far it has decreased), the complexity of the architecture precludes alacrity.

For comparison, Apollo landed on the Moon in 8 years. Today's lander is more of a large rocket. It has been under development for the same amount of time as the Apollo Program and needs new engines and a bigger core stage to increase payload capacity. It could be an important capability for the country but is unlikely to beat China's projected timeline to the lunar surface.

The Gateway

The Cislunar domain is the ultimate high ground for national security, and the Moon itself is a source of critical minerals and a potential solution to our long-term energy needs due to Helium-3. In the long term, we need permanent surface activity using in-situ resources. Administrator Sean Duffy is correct that we need nuclear fission power on the Moon and it should be accelerated.

A key component of the Artemis Program that will allow us to maintain a presence around and on the Moon is the Gateway. The Gateway provides sustainable access to the entirety of the Moon when coupled with a lander. It is also the component of Artemis where our international partners are shouldering the majority of the investment—over 60 percent. If desired, it is technically possible to leverage funding in the OBBBA to accelerate and launch Gateway in 2028, ahead of the projected landing by China.

Low Earth Orbit and Commercial LEO Development

When the United States leaves a gap in capability, our geopolitical competitors fill it. The United States and the world became dependent on the Russian Soyuz with the retirement of the Space Shuttles and the 9-year gap before Commercial Crew was ready. We don't want to leave a gap in LEO and watch our international partners join China's new space station.

Fortunately, Congress, particularly the Chairman, has repeatedly, across multiple administrations, ensured the continuation of the International Space Station and prevented a gap in permanent human presence in low Earth orbit.

We are close to having commercial space stations that can both meet NASA requirements and close a business case by providing a location for industry to undertake activities where we've seen incredible early returns on the ISS—things like pharmaceuticals, advanced materials, and biomedical engineering. This is a place where both Congress and the Administration agree: we need to transition to commercial space stations as soon as possible.

Earlier versions of this Committee's NASA authorization have included a provision which sets permanent human presence in LEO as the policy of the United States. That's the right policy. I recommend the NASA Authorization include the following:

- No gap in a permanent human presence in LEO;
- Replace the ISS with fully mission capable (FMC) commercial space stations (not temporary space stations or partially tended space stations);
- Select 2 providers now and commit that NASA will procure at least a minimal set of services from those providers; and
- Require providers to compensate NASA for a portion of the certification. If NASA isn't the only user, NASA shouldn't bear the entire expense of certification.

By doing this, we can ensure a timely LEO transition, avoid a gap in access, and avoid ceding LEO superiority to China.

Science

Finally, I do want to speak a bit on the Science Mission Directorate. I appreciate the Administration's focus on human spaceflight—if we are going to beat China, it

has to be a priority. But there is a lot of science that is valuable to our life that isn't directly applicable to human spaceflight, and it should be preserved.

Take, for instance, planetary defense. Preserving life and property is a critical function of the Federal government, and NASA is uniquely situated to carry out planetary defense.

Unfortunately, the budget proposes to cut key planetary defense missions, like OSIRIS-Apex. This would be misguided. We have an unbelievable opportunity to study an asteroid the size of a football stadium passing closer than the GEO belt. The data we get on the behavior of an object like this will be invaluable in our understanding of near Earth objects and planning future planetary defense missions. I hope Congress maintains the mission and others like it.

NASA Earth Science provides data we use every day—monitoring weather, water, fire, space weather, air quality, agricultural outputs, and more. These missions supply data that is vital to our economy and is leveraged by people and businesses alike. Not all Earth Science is partisan and I would ask Congress to consider authorizing agreeable programs.

Conclusion

Thank you again for the opportunity to appear before you. I look forward to your questions.

Chairman CRUZ. I thank the Administrator. I will say I am not sure we need to codify the Wrath of Khan any more than we need to codify gravity or that the sky is blue. There are some things that are indisputably true, and that would be one of them.

General Shaw.

STATEMENT OF LIEUTENANT GENERAL JOHN SHAW, FORMER DEPUTY COMMANDER, U.S. SPACE COMMAND

General SHAW. Great. Chairman Cruz—or do I say Captain Cruz?—Ranking Member Cantwell, and members of the Committee, thanks for the opportunity today. And by the way, I am also grateful to share this table with some amazing people here, and look forward to our session and what they have to say today.

It was the honor and time of my life to serve our great nation and lead our phenomenal warfighters for 33 years in uniform in our United States Air Force and United States Space Force. Throughout my military service, I also had the privilege to work closely with NASA, NOAA, and other governmental civil organizations across many endeavors. But I am also grateful to have had the opportunity the last 2 years, since my departure from uniformed service, to work with and in the commercial side of our Nation's space business. It has given me a fresh and broader perspective on how to both envision and realize our Nation's future in space in totality, and how to bring to bear our combined national strengths to best thwart China in the years to come in this crucial arena.

My bottom line up front for the Committee today is that I am an advocate for, and a champion of, a unified grand space strategy for our Nation for the Earth-Moon system and beyond. Yet such a grand strategy—which would unify and synergize our national efforts across civil, commercial, and national security activities in pursuit of common goals, opportunities, and capabilities—does not currently exist. And I believe our mission to return Americans to the Moon can be a powerful, and a central driver for, as well as the beneficiary of, such a strategy.

During my military career, I watched and studied—as any good soldier would of a potential adversary—as China slowly but surely

developed and deployed its own civilian and military space capabilities and set its own agenda for space achievements. It is clear to me that the Chinese Communist Party is already employing its own integrated grand strategy for the Earth-Moon system, with only superficial distinction between civil, commercial, and national security activities, and all focused on a common purpose. And as the Senator has already made my next point, I think if we do not unify and synchronize efforts, may find ourselves, rather than in a leadership position, in a position of increasing disadvantage as we get further into this century.

Human progression in any domain both has and will involve a robust mixture of exploration, economic opportunities and growth, and security activities to set conditions for success. Space is no different.

And by the way, I realize I am probably representing, of those three things, exploration and commercial and economic growth, and national security, I am representing the national security end here. But I also want to say, I am passionately excited about all three of those things, and that is how we are going to succeed as a nation.

A notional example goal for a grand space strategy objective would be to set the conditions, standards, and proper incentives for the establishment of an orbital and lunar logistics infrastructure, one that would enable increased capabilities and performance for space activities of all kinds throughout the Earth-Moon system. Such an infrastructure would include on-orbit manufacturing, assembly, refueling, replenishment, and other forms of servicing. We already know that we will need such an infrastructure to sustain human presence on the Moon, solely from just the exploration approach. But such an infrastructure could and will benefit Dynamic Space Operations for national security platforms as well as for commercial endeavors.

Yet, our national approach to space logistics to date has appeared disjointed and inconsistent to those in the commercial community—and I hope my panelists maybe address this and see their perspective—is seen as inconsistent to those who might want to invest in those capabilities.

The Chinese are already matching and perhaps even outpacing us in this logistics pursuit. Here is a recent example. Just in the last few weeks, this summer, as observed by open sources and reported in media, we have seen China perform a docking and apparent refueling operation between its SJ-21 and SJ-25 platforms in geosynchronous orbit. Following that fuel transfer activity, the docked spacecraft together—this was this last month—performed the largest single maneuver in geosynchronous orbit ever yet conducted, likely in excess of 330 meters/second. That is a lot, actually, well, at least by today's standards. Some day that will be a pitance, but today that is a lot.

Other examples of areas where I believe we could move faster and more effectively under a unified strategy include cislunar space domain awareness, and a cislunar communications architecture, both, again, necessary for sustained human presence on the Moon.

I am also supportive of swiftly developing nuclear fusion power solutions in space, which are compelling to sustained operations on

the lunar surface, but also could better enable national security activities, such as in the form of nuclear propulsion, and could unlock new commercial opportunities and benefits, as well.

I will point out that China is developing or has already fielded capabilities in each of these example areas: cislunar domain awareness, cislunar communications, and space nuclear power.

The challenges are great, the matter is urgent, but I am optimistic we can indeed, via a unified grand strategy for space, thwart China's ambitions and continue the United States' leadership in this ultimate high ground.

In the words of a different Star Trek captain, let's engage and make it so.

I look forward to your questions.

[The prepared statement of General Shaw follows:]

PREPARED STATEMENT OF LT. GEN. JOHN SHAW, FORMER DEPUTY COMMANDER,
U.S. SPACE COMMAND

Good morning, Chairman Cruz, Ranking Member Cantwell, and members of the Committee. Thank you for the opportunity to testify today on this important topic and pursuit for our Nation. I am also grateful to share this table with some truly amazing people, and I'm honored to be here with them today as part of this session.

It was the honor and time of my life to serve our great nation and lead our phenomenal warfighters for 33 years in uniform in our United States Air Force and United States Space Force. Throughout my military service, I also had the privilege to work closely with NASA, NOAA, and other government civil organizations across many endeavors. But I'm also grateful to have had the opportunity in the two years since my departure from uniformed service to work with and in the *commercial* side of our Nation's space business. It has given me a fresh and broader perspective on how to both envision and realize our Nation's future in space in totality, and how to bring to bear our combined national strengths to best thwart China in the years to come in this crucial arena.

My bottom line up front for the committee is that I am an advocate for, and champion of, a unified grand space strategy for our Nation for the earth-moon system and beyond. Yet such a grand strategy—which would unify and synergize our national efforts across civil, commercial, and national security activities in pursuit of common goals, opportunities, and capabilities—does not currently exist. I believe our mission to return Americans to the moon can be a powerful driver for, as well as beneficiary of, such a strategy.

During my military career, I watched and studied—as any good soldier would of a potential adversary—as China slowly but surely developed and deployed its own civilian and military space capabilities and set its own agenda for space achievements. It is clear to me that the Chinese Communist Party is already employing its *own* integrated grand strategy for the earth-moon system, with only superficial distinction between civil, commercial, and national security activities, and all focused on a common purpose. I believe if we do not unify and synchronize *our* efforts, we will find ourselves, rather than the space leaders we are today, instead in a position of increasing disadvantage in space as we progress further into this century.

Human progression in any domain both has and will involve a robust mixture of (1) exploration, (2) economic opportunities and growth, and (3) security activities to set conditions for success. Space is no different.

A notional example goal for a grand space strategy would be to set the conditions, standards, and proper incentives for the establishment of an orbital and lunar logistics infrastructure—one that would enable increased capabilities and performance for space activities of all kinds throughout the earth-moon system. Such an infrastructure would include on orbit manufacturing, assembly, refueling, replenishment, and other forms of servicing. We already know we will need such an infrastructure to sustain human presence on the moon, solely from an exploration approach. But such an infrastructure could and will benefit Dynamic Space Operations for national security platforms as well as commercial endeavors. Yet, our national approach to space logistics to date has appeared disjointed and inconsistent to those who might seek to invest in these capabilities. A clear goal with effective ways and means to achieve it would get us to this vital and inevitable infrastructure.

The Chinese are already matching and perhaps even outpacing us in this particular pursuit. Here is a recent example: just in the last few weeks (as observed by open sources and reported in media), we have seen China perform a docking and apparent refueling operation between its SJ-21 and SJ-25 platforms in geosynchronous orbit. Following that fuel transfer activity, the docked spacecraft together performed the largest single maneuver in geosynchronous orbit ever yet conducted, likely in excess of 330 meters/second.

Other examples of areas where I believe we could move faster and more effectively under a unified strategy include *cislunar space domain awareness*, and a *cislunar communications architecture*—both, again, necessary for sustained human presence on the moon.

I am also supportive of swiftly developing *nuclear fission power solutions in space*—which are compelling to sustained operations on the lunar surface, but also could better enable national security activities, such as in the form of nuclear propulsion, and could unlock new commercial opportunities and benefits as well.

I will point out that China is developing or has already fielded capabilities in each of these example areas: cislunar domain awareness, cislunar communications, and space nuclear power.

The challenges are great, the matter is urgent—but I am optimistic we can indeed, via a unified grand strategy for space, thwart China's ambitions and continue the United States' leadership in this ultimate high ground.

Thank you again for this opportunity to testify today. I look forward to your questions.

Chairman CRUZ. Thank you to each of you.

Mr. Bridenstine, let's start with China, a topic you addressed at some considerable length. China is on an aggressive timeline to put astronauts on the lunar surface by 2030, and they appear on track to do so. They are also currently operating a space station right now in low Earth orbit.

Mr. Bridenstine, China is racing to control the Moon and low Earth orbit, and they are not shy about using space to expand their power on Earth. If America doesn't beat them, if we cede the lunar surface or continuous presence in orbit to Beijing, what does that mean for our national security, our economy, and America's leadership?

Mr. BRIDENSTINE. Very important question. So here is how I view things, and I think the General will appreciate this, from my time as a lieutenant in the Navy. We did Joint Professional Military Education, and we learned this thing called the DIME Theory of National Power. And in each of those elements you have, you know, it's an acronym, DIME—diplomatic, information, military, economic power.

When I was at the helm of NASA, my goal was to always think about what we are doing in those elements. How does this advance diplomatic power? How does it advance information power, military power, and economic power?

On the diplomatic side, you mentioned the International Space Station and the next-generation commercial space stations. On the diplomatic side, we have 15 different countries that are operating the International Space Station today. We have had astronauts from, I think, 21 different countries at this point. We have had agreements with over—actively, I think, we have got over 600 or 700 agreements now, internationally, as it relates to missions.

NASA is a key element of diplomatic power for this country. I will tell you, I don't think it is often used correctly. I mean, we could put it on the table for a whole host of, you know, kind of carrot-and-stick kind of activities, to benefit the United States of

America and an America First policy. That is the way I thought about it when I was the NASA Administrator.

On the information power side of things, you know, one of my big things, one of my first eye-opening experience at NASA, when we landed Insight on Mars. This was a lander that was going to land on Mars and help us understand Mars quakes. Like how does Mars, how is it organized inside?

Well, when we landed Insight on Mars, it was on the cover of every newspaper worldwide. That is amazing information power, including one newspaper, it was the hardline newspaper of the Islamic Revolutionary Guard Corps in Iran. Now, I am not saying we want to win their press, but at the end of the day it was a story about how we landed on Mars.

Chairman CRUZ. But their Sunday comics are excellent.

Mr. BRIDENSTINE. But it was a story about how we landed on Mars, and it was a story about how we did it, when we did it, what we were doing, and it had a list at the end, was all of our international partners that participated with us in that.

This is a newspaper in Iran, where they don't get good information about the United States of America. But when we land on Mars it changes things. It changes the perception of young people toward this country that we love. And I think that is an important power, information power.

Of course, everybody likes to talk, you know, Apollo 11, when we landed on the Moon and the whole world watched. You know, that's information power that we reference even today. You know, if we can land on the Moon, why can't we do these things, you know, that kind of thing.

On the military side, NASA is not strong. We don't play military. We don't report to the Secretary of Defense. But a lot of our technologies and capabilities, in fact, have dual-use capability.

One thing that concerns me greatly right now is the devastating consequences happening to the Jet Propulsion Laboratory out in California, JPL. They are the ones that built all the Mars landers. They are the ones that have landed on Mars nine times in history. But a lot of that technology, make no mistake, has military applications, and we are at risk of losing a lot of that. So I think that is important to note, as well.

Finally, that is the military side of things, but it is really not where NASA plays. NASA plays in exploration science discovery. The E—and this goes back to the opening statements—the E is economic power. When it comes to pharmaceuticals, regenerative medicines, advanced materials, an article came out, China is using their space station to create new, advanced materials for hypersonics, materials that, my understanding is we don't have right now, although maybe somebody knows something I don't know.

At the end of the day, we have to use microgravity where we know atoms and molecules organize differently. We have to use it to our advantage, and advanced materials, China is doing that. And we are not doing it the way we should, and we are at risk of losing it.

So all of those elements, I think, are important when we think about the great power competition with China. We need to think

about NASA being used for diplomatic power, information power, military power, and economic power.

Chairman CRUZ. Thank you. Gateway will be America's eye in the sky in cislunar space, extending our lunar surface program by enabling longer missions, heavy equipment delivery, and protection of U.S. assets, while paving the way for advanced infrastructure, like Interim Administrator Duffy's goal of a lunar nuclear reactor by 2030. Meanwhile, China has made it clear that it intends to build its own cislunar station as a platform to dominate the Moon and to pursue critical resources such as Helium-3.

Mr. Gold, in your judgment, why is it critical that the United States lead with Gateway and cislunar before China builds its own cislunar station and uses it to control the Moon?

Mr. GOLD. Thank you, Senator. When I was at NASA I got a briefing on our ability, or should I say inability, to monitor Chinese activities in cislunar space. I didn't sleep for a week. You know, you hear democracy dies in darkness? Our freedom could die in the depth of space if we are not able to monitor and understand what is happening with space situational awareness around the Moon.

And relative to nuclear on the Moon, you mentioned Helium-3, it is not just about the Moon. It is about Earth. The countries and companies that control the Moon will control the Earth. It is just a matter of time. Rare earth elements, Helium-3—we need to be able to extract these resources. We need to be able to learn to live off the land.

I am a native of the great state of Montana. I did a lot of camping and fishing back in the day. I cannot imagine going on those camping trips if I had to bring all of my air, all of my water, all of my food, all of my oxygen. You cannot have a sustainable, robust presence or support economic activities if you can't live off the land.

And we can't do that without nuclear, and I cannot praise Secretary Duffy enough for acknowledging that this is not just about going back to the Moon. This is about going back to the Moon, harnessing its resources for the Earth, and establishing infrastructure and a permanent presence. The Secretary gets that, and I applaud him for moving forward with nuclear, and, by the way, breaking news, our friend Amit is now the Associate Administrator of NASA.

And again, I very much appreciate Secretary Duffy's decisive action, his decisive leadership, in elevating the head of the Moon to Mars Program to Associate Administrator, the highest civil servant post in NASA. That sends an important message, not just to NASA but to our international partners, even to China, that we are back. We are reigniting the torch of Artemis, and we are going to go forward to the Moon. I can tell you NASA civil servants needed to that, and again, I'm very grateful to Secretary Duffy for making that point.

At Redwire we are developing a system called Mason. It is going to use microwaves to center regolith, to create landing pads, berms, roads. We need to be able to build that infrastructure.

But more than anything, we need to be able to rebuild our credibility here on Earth. When I was negotiating the Gateway agreements with the European Space Agency—thank you for that privilege, Jim—they learned one thing about popular culture, maybe from the comics in the Tehran Times there, Lucy and the football.

They told me, “Lucy and the football. Why should we sign up with you? The Trump administration will be gone in a year and a half. We would look foolish for making that investment.”

And I told them, “You’re right. Don’t listen to me. They’re justifiably skeptical. NASA has failed to sustain a beyond-LEO human space flight program since Apollo. Failure hasn’t just been an option. It’s been a certainty.”

So how did I convince the Europeans? Senator Cantwell, I had your help. And I told them, “Don’t listen to me. Listen to Senator Cantwell. Listen to Senator Nelson. Listen to the bipartisan coalition that Jim Bridenstine created. Because if we lose, then they will carry forward.”

And if we cannot show that we can be a good partner, that we can be a reliable partner, all the benefits that we talked about—diplomatically, economically—will go to others.

We are talking a lot about Star Trek. The reason I love Star Trek, not just the adventure, not just the stories, but because it said we are not going to have just better technology but a better future in space. We launch not just our astronauts and hardware. We launch our values. And if we cannot move forward with Gateway, if we cannot move forward with Artemis, we will lose that future to the Chinese.

Chairman CRUZ. Well, thank you both for your testimony. I will say I was disappointed with both of you that you guys left Matt Damon on the surface of Mars. But other than that you both did an excellent job.

Ranking Member Cantwell.

Senator CANTWELL. Thank you, Mr. Chairman, and thank you all for illuminating this issue of why we need a grand strategy. I think it is a good terminology that equates to the notion that the time is here to think bigger about the implementation of all the things. It reminds me, sitting here, of how a colleague once said to me, “You know, your state should be called Jefferson.” I said, “My state should be called Jefferson?” He said, “Yes. It was President Jefferson who basically made the big decision to send Lewis and Clark at a critical moment in our country’s history to go all the way across the United States to try to find if there was a faster path, and laid claim to the Pacific Northwest.” Because other people were already there, obviously, by ship. And the President, Jefferson, saw the importance of America’s expansion all the way to the Pacific coast.

So anyway, we are still proud we are called Washington.

But it brings up this point about the predicate of getting there first, and I do not know if this is you, Mr. Gold, or Lieutenant General Shaw. But there are areas, particularly the South Pole of the Moon, that are critically and strategically important, and getting there in a timely fashion to claim those resources or claim that space seems to be just as critical as Jefferson’s decision to get us all the way out to the Pacific. I don’t know if one of you wants to comment on that.

Mr. GOLD. Senator, I would say even more critical than Jefferson’s decision, because this doesn’t affect a country. This affects the whole world. And you are exactly right. The Moon is a large place, but the number of locations that have the combination of water ice,

sunlight, and other aspects that we need are actually relatively limited, and we could lose those to the Chinese if we don't move quickly.

Additionally, the countries that get there first will write the rules of the road, for what we can do on the Moon, how we act. We have had tremendous success with the Artemis Accords. Fifty-six countries have signed. The Chinese only have 13 for their International Lunar Research Station program. But if we are not first, trust me, those numbers will change.

And the fear? China will eventually outspend us in space. It is inevitable. We must out-entrepreneur them. And that is why I am so grateful for one of your constituents, Blue Origin, for example, and for some reason this does not get, I think, enough play. They have spent billions—billions—of their own money to support the HLS system. They are going to launch a Mark I spacecraft to the Moon, paid for all on their own dime.

Senator CANTWELL. I am assuming everybody is for the redundancy of the lunar system, the lander system.

Mr. GOLD. Yes.

Senator CANTWELL. Yes. Yes.

Mr. GOLD. Absolutely.

Mr. BRIDENSTINE. We are grateful for your leadership to make that happen.

Mr. GOLD. Which we desperately need, because you have to have to. You need that for efficiency. You need that for competition. You need that for safety.

But again, if we do not get out there and get there first, we will lose real estate, we will lose the rules of the road, and we will lose the international partnerships and the economic benefits. In Helium-3, that could be a new, clean power revolution that we are going to let the Chinese Communist Party have. Let's step up—

Senator CANTWELL. We do have some companies already working on this in the Northwest.

Mr. GOLD. Absolutely.

Senator CANTWELL. We are very proud of that.

So Lieutenant General Shaw, so this notion—you know, I get up this morning and see all the headlines from China, and everybody is there together, including Prime Minister Modi and Kim Jong Un, although we do not have all the photos of them, and you could see that somebody could really start focusing on new alliances. What is it about the grand strategy that is so critical for us to implement, from a military perspective? How can you describe it in the context of losing this first mover advantage that would be so critical to the alliances and partnerships that would help us?

General SHAW. Senator, I think as some of the other panelists said, this Earth-Moon system, these opportunities on the Moon, are not just for exploration alone, any more than the Lewis and Clark expeditions were just, oh, I wonder what's out there. No. They were about to understand the environment, to scope it for economic growth, and, of course, there were security issues along the way. I point out that Clark was a lieutenant in the U.S. Army. But there to provide security and understanding of what our borders and frontiers were.

So we need to approach the Moon the same way, that it is all of these pieces, all of the DIME that Honorable Bridenstine mentioned.

One of these examples that we have talked about, where I do not think we are—where we could do this better as a nation, would be cislunar domain awareness. There are going to be needs for that, just for human presence in and around the Moon, to understand that domain. What debris might be in lunar orbit? It is a different kind of regime than low Earth orbit that we are used to, but there is the possibility that there will be things in orbit, and we want to understand what is there. We want to understand what possible mischief could be going on. It is easy to hide things way, way out there. We want to understand that.

So not only protecting humans and human exploration but there is a national security need, to understand that environment as part of the full Earth-Moon system. And to my knowledge right now, the Department of Defense isn't really focusing that much on that. If there is a national need to do it, why not have the Department of Defense perhaps be part of that solution and develop the capabilities it is going to ultimately need anyway.

So that is this idea of where we probably could do things in a much more coordinated and synergistic fashion than we are currently doing.

Senator CANTWELL. Well, I am definitely very concerned about our communication security writ large, and I do think more of defense is moving into space and satellite effects of communications. And then I worry that if somebody is going to be on that frontier of the latest, of technology communication in a cislunar environment, that has to be us, and we have to understand what the ramifications are of that system. Is that not correct?

General SHAW. That is absolutely correct. And again, I would like to point out that China sent seven payloads to the Moon last year. Six of them were communications focused. They were not scientific experiments. They were communications focused, the building blocks of a communications architecture. So they are already demonstrating the fact that they are trying to build that infrastructure that I talked about before.

Senator CANTWELL. And do you have any idea what that infrastructure could do, that would be a military concern?

General SHAW. The term "dual use" has already been brought up by the panel. Any capability that could be used for scientific or exploration or even economic purposes invariably is going to have some sort of national security use to it, of some kind.

As an example, in this particular case, if there are Chinese national security payloads operating in the broader Earth-Moon system, they could leverage that communication architecture network to have continuous communications with those platforms, rather than relying on strictly terrestrial relay.

Senator CANTWELL. Oh, well, a big advantage there. Thank you, Mr. Chairman.

Senator MORAN [presiding]. Senator Cantwell, thank you. Senator Fischer.

**STATEMENT OF HON. DEB FISCHER,
U.S. SENATOR FROM NEBRASKA**

Senator FISCHER. Thank you, Mr. Chairman. Thank you, General, for your comments about defense. I chair the Subcommittee on Strategic Forces on Armed Services, and we have had numerous discussions on that since we have jurisdiction over space as a warfighting domain. So I appreciated your comments.

You guys are really good storytellers. I have a short amount of time here so I would like specific answers. I need to leave for another hearing, and there are some things I would like to get through.

Mr. Gold, I am not picking on you first, but Mr. Gold, should China be the first to establish a permanent presence on the Moon, there would be serious consequences for Americans. You have spoken to that in the past, as has the Administrator. I want to hear some specific examples from you on how the lives of Americans would be impacted should China establish control of the Moon's resources? So Americans can reach out and touch what would really happen to their lives.

Mr. GOLD. The potential wealth of the Moon is extraordinary and uncannily even unknown.

Senator FISCHER. You are telling me a story.

Mr. GOLD. Well, let me put it this way. China lands on the Moon. The next day we see tremendous benefits to China geopolitically, where our allies turn to them, not only for space exploration but for national security agreements, for trade agreements. The meeting that is occurring now between China, India, and Russia that you are seeing today, if China lands on the Moon first, that will deepen and strengthen those economic eyes. China is very good at leveraging space to drive the DIME assets that Jim Bridenstine and General are talking about. If they get there first, we will see a global realignment that will impact our economy, our tax base, our ability to innovate, and our national security in terms of diplomacy and geopolitics, that will affect security, and many other aspects of our daily lives.

Senator FISCHER. Thank you very much. Administrator, while at NASA you helped lead the Artemis Accords and established that framework for the principals to guide civil space exploration. China has their own framework, the Internal Lunar Research Station that is there. Can you, first of all, speak to the importance of the Accords, and then speak to the risk that we would see with those principals if they start to erode, the risk we have there for future deep space exploration, since China then would establish that permanent presence on the Moon?

Mr. BRIDENSTINE. Excellent question. A couple of things I think are important to note. When we established the Artemis Accords it was because—and this is important, so important—we went to an event where there were a lot of international players in the space domain, and we said, “Hey, we are thinking about creating a Moon program. In fact, we are going to create a Moon program. If you would like to participate, come to a meeting.”

We had like 26 countries show up, and they were so enthusiastic about being part of the Moon program it was overwhelming. And so when that was over, I came back and I called Mike Gold, and

I said, "Look, we need to figure out a way to use this as a compelling way to get people to behave properly in space, because in many ways they don't." And so I actually got Mike Gold to come to NASA to run this effort called, what he termed the Artemis Accords.

And at the end of the day, what we have to have is rules. So if we are going to go extract resources from the Moon, there have to be rules around that. And those rules, I think, are established in law and precedent, when you think about international waters. You know, just because you extract tuna from the ocean doesn't mean you own the ocean, but you get to own the tuna. And if you extract energy from the ocean, you don't own the ocean but you own the energy.

Those same principles should apply to the Moon. If you extract platinum-group metals or what we call rare earth metals, or in this case, rare lunar metals, if you extract that from the Moon and you apply your sweat and your equity and your effort to get those resources, you don't own the Moon. The Outer Space Treaty says you can't appropriate the Moon for national sovereignty. However, you can own the resources that you extract from the Moon, and I think that is an important principle that we, as Americans, need to be leading the world on. And that is what the Artemis Accords were all about. And that is why I got Mike Gold to come lead that effort.

Senator FISCHER. Great. Thank you. Also, Administrator, when we look at trying to remain competitive with China in deep space there is going to be an increased demand for commercial launches. Do you assess that demand will outstrip existing launch capacity, and if so, what can be done in order to expand that capacity that we currently have?

Mr. BRIDENSTINE. Oh my gosh, that is an important question, and very challenging. The answer is yes, we are already over-capacity. Our launch facilities are basically stretching and twisting and doing everything they can to put more launch capability into the same amount of space.

A couple of things I think it is important to note. I want to be clear. The architecture for the Artemis program is strained, to say the least. I would also say that we need, in many cases we need Starship to be successful for a whole host of capabilities. It is also true that if they do what they are setting out to do, there are going to be over 100 launches from Cape Canaveral and Kennedy Space Center per year, from Starship, and in each one of those launches that also means there is going to be testing, there is going to be landing, there is going to be a lot of different things happening. Each time that is going to end up shutting down those facilities. And it puts us in a position where we could end up with basically one launch provider, if we don't figure out how to solve this problem.

I do believe that over time, you know, there are going to be other opportunities to launch from different locations. We are not there right now. I am talking about inland launch. You know, from Oklahoma we have a Space Port. Right now we would have to drop something on Kansas, and I know Senator Moran does not want us dropping anything on Kansas. So we do not want to do that.

But I do think it is important that we try to find alternative solutions for launch, initially on the coast, but eventually we are going to have to come to inland launches.

Senator FISCHER. When you look at overall launch capacity and the impact that these heavy launch vehicles have on the existing infrastructure, I think, yes, we do have to be able to look beyond where we are now. And Space Force determines the launchpad allocations, so we have a tie-in there between these committees, each within their own jurisdiction, specific jurisdiction over different parts of what we are discussing here today.

Thank you.

Mr. BRIDENSTINE. Thank you.

Senator MORAN. Senator Kim.

**STATEMENT OF HON. ANDY KIM,
U.S. SENATOR FROM NEW JERSEY**

Senator KIM. Thank you all for coming on out here. You know, Mr. Bridenstine, I would love to just start with you. There has been a lot of conversation about the different national security implications, and I agree with that. As someone who has worked in national security my whole career, it is important that we keep our foot on the gas.

As I am trying to explain to the people in my state of New Jersey what is the benefit we get out of the space program, especially from a commercial aspect in terms of just implications to people's daily lives, our economy, how do we go about doing that? What is the best argument that you have come across?

Mr. BRIDENSTINE. Oh my. OK.

Senator KIM. You raise some of the potential exploration benefits of microgravity, of biotech. I would love for you to expound on this and really try to help us hit home to the American people the importance of this.

Mr. BRIDENSTINE. Yes, sir. I would summarize it with there are a lot of ways to talk about it. But I would say the way we communicate, a lot of use Internet broadband from space. People here are familiar with DirecTV, DISH Network, as well. The way we communicate now is highly dependent on space. Even in our terrestrial wireless networks, our cellphones are dependent on a timing signal that comes from GPS. So even our wireless networks are dependent on space.

But the way we communicate, the way we navigate—GPS, for example, is critically important—the way we produce food, we are increasing crop yields, reducing water usage, the way we produce energy and the way we do it cleanly, the way we predict weather. The way we understand climate, and there is a lot of partisanship around the climate issue. But at the end of the day we have got to know what is happening. And there are ways that we can use our space assets to understand how the climate is affected by what we do here on Earth.

Senator KIM. One thing I saw NASA do that I wasn't fully aware of was just how much the applications are for agriculture, for instance, especially when it comes to what you were just saying about climate and understanding crop, storm systems, et cetera.

I wanted to just bring in something else. I just did a CODEL trip out to South Korea and Japan, and it really just got me thinking, as I am listening to you and this panel, thinking about just our space cooperation, you know, just the role that it plays with other countries. And, Administrator, I would like to start with you but open it up, just what you see in terms of South Korea and Japan, places where we can build upon, especially when it comes to accelerating Artemis, building a counterweight to China's space partnership with Russia.

And look, there is no doubt we saw those images with Modi standing next to a lot of these leaders. How can NASA work with India to build on the NISAR partnership to advance shared space, science, and exploration goals? I am just trying to think about how it is that we can try to anchor that relationship, as well.

Mr. BRIDENSTINE. Yes, wonderful question. I think when it comes to South Korea and Japan, Japan specifically has been a long partner with the United States on space exploration, from the International Space Station, they have modules on the International Space Station, they have got experiments on the International Space Station, they have rockets that resupply the International Space Station. They are among our best partners on the International Space Station.

And, of course, they are one of the early adopters of the Artemis Accords. In fact, I think, Mike, weren't they in the first eight?

Mr. GOLD. They were the first to sign.

Mr. BRIDENSTINE. The first.

Mr. GOLD. And the reason the English is so good in the Accords is because of the corrections the Japanese made. They speak English better than we do.

Mr. BRIDENSTINE. There you go. So I think—

Senator KIM. I do not know if I feel super great about that, what it says about us.

Mr. BRIDENSTINE. But I think all of those are important international partnership. And then, of course, on the South Korean side, they also signed onto the Artemis Accords, and they want to do more and more in space. And they have the capability to do that, and since they signed the Artemis Accords we want to bring them into that fold and have them participate fully in the missions.

Senator KIM. Go ahead.

Mr. BRIDENSTINE. Sorry. And Senator, in regard to the Artemis Accords, what is really wonderful to see is it has created an ecosystem, a family of nations. When we were back at NASA during the launch of the aptly named HOPE mission by United Arab Emirates, that was a spacecraft built by UAE that was powered by a partnership that began between UAE and Korea, where UAE did not have the technical capability, they went to Korea, they helped them build these spacecrafts. Then they brought it domestic, and then it was launched on a Japanese spacecraft with American assistance from Colorado. During this launch we heard overlapping Japanese, Arabic, English, and even Korean back during some of the technical conversations.

That is the future that we want. And when it comes to national security, that is the coalition that will keep us safe in China, if we can continue with the Artemis program.

Senator KIM. Yes. Well look, I am almost out of time, so I will just say, you know, I worked in diplomacy before, did a lot in terms of different bilateral, multilateral relationships. I have never seen another issue that can really solidify some of these relationships and stay out of the day-to-day politics, stay out of some of the geostrategic conversations, and really just be able to have that kind of pure expert, science-to-science kind of partnerships. I think there is a lot here to build off from. I am excited about some of the energy I see on this Committee. So thank you for your testimonies today, and I yield back.

**STATEMENT OF HON. JERRY MORAN,
U.S. SENATOR FROM KANSAS**

Senator MORAN. Thank you, Senator Kim. On behalf of Senator Cantwell, she has an article from *Air & Space Forces Magazine*, dated March 28, she would like to have admitted to our record. Is there any objection? Without objection, so ordered.

[The information referred to follows:]

AIR & SPACE FORCES MAGAZINE



A United Launch Alliance Vulcan VC2S rocket launched the first certification mission from Space Launch Complex-41 at Cape Canaveral Space Force Station, Fla., in January. The test carried two payloads: the Peregrine Lunar Lander and the Celestis Memorial Space deep space Voyager mission, known as the Enterprise Flight. **Joshua Conti/USSF**

WHY CISLUNAR SECURITY MUST BE A SPACE FORCE CONCERN

March 28, 2024

Think of the Moon as the First Island Chain Off the Coast of Earth.

Global powers and new space entrants are racing to the Moon and the cislunar regime, an area extending beyond geosynchronous orbit out to more than 275,000 miles. In this region of space, spacecraft trajectories are influenced by the gravitational pull of *both the Earth and Moon*. There, few established norms exist to govern the multinational players and their scientific, economic, and geopolitical objectives.

Several countries are planning robotic missions, and some are pursuing a permanent human presence on the Moon. All told as of this writing, some 106 missions are planned for cislunar space this decade, representing the efforts of 19 countries and the European Space Agency.



**Col. Charles S. Galbreath, USSF (Ret.),
Senior Resident Fellow for Space
Studies, Mitchell Institute for
Aerospace Studies.**

Download the entire report at

<http://MitchellAerospacePower.org>.

Unlike the race to the Moon between the United States and the Soviet Union in the 1960s, this new space race involves dozens of countries, dynamic geopolitical tensions, and technical capabilities associated with sustained presence. That added complexity increases the urgency to view this regime in a new light: The U.S. Space Force and U.S. Space Command must begin taking steps today to ensure free and open access to cislunar space—or risk ceding the region to others who move more quickly.

Already in 2024, we’ve seen three missions head to the Moon. Japan’s Smart Lander for Investigating the Moon (SLIM) saw the Nation became the fifth nation to land on the lunar surface, though it suffered a power issue after landing. The U.S. commercial effort Peregrine, the country’s first lunar landing attempt in decades, suffered a propellant leak once in space and burned up as it reentered the Earth’s atmosphere. Finally, Intuitive Machines reached the lunar surface, marking the first successful commercial mission to the Moon and the return of the United States to the Moon’s surface after over 50 years. All of these efforts encountered problems, underscoring the complexity and challenges of this new space race.

Even with the diverse set of nations heading to the Moon, there are now two main teams involved in the current race. On one side is the United States and an extensive group of aligned nations who have signed the Artemis Accords. This agreement reaffirms the peaceful intentions of space exploration and contains provisions on transparency, interoperability, emergency assistance, registration of objects, sharing scientific data, preservation of space heritage, extraction and use of space resources, deconfliction of activities, and debris mitigation. Many of these aligned countries enjoy advanced space programs, like Japan and India. They are joined by non-space-faring nations that support the peaceful and transparent approach outlined in the accords.

On the other side of this equation, China and Russia have partnered in the International Lunar Research Station (ILRS), along with Venezuela, Iran, the United Arab Emirates (UAE), and the nations of the Asia-Pacific Space Cooperations Organization (APSCO). Plans call for the ILRS to consist of a facility near the South Pole of the lunar surface and a station in cislunar space used to aid communication and transportation to the lunar facility.

In this race, either the United States and its partners arrive first and establish customary practices of safe and responsible collaboration, or they risk relinquishing key interests and governing principles to China and Russia. Given the lack of established international norms, this will be just like any other era of territorial exploration and expansion—those who arrive first set the terms. China’s ambition to supplant the United States as the world leader means it sees this race as an opportunity to shift the global balance of power. So, losing this race could seriously disadvantage the U.S. in the future.

Understanding the Cislunar Regime

Cislunar space is an incredibly dynamic region influenced by numerous forces and having caustic conditions. Mastering it demands collaboration from civil, commercial, and national security entities.

Unlike operations in Earth orbit, which are predictable and follow stable paths due to the Earth’s powerful gravitational force, spaceflight dynamics change dramatically as objects move beyond geosynchronous orbit and begin to come under the

gravitational pull of the Moon. These competing forces greatly complicate spacecraft trajectories.

In the cislunar regime, there are five special locations where the gravitational pull of the Earth and the Moon balance and an equilibrium is attained. Known as Lagrange points, their gravitational equilibrium enables spacecraft to remain near the points and transit between them while using only minimal fuel. Their positions relative to the Earth and Moon also offer a commanding vantage of the cislunar regime, making them highly valuable to future domain awareness, communication, navigation, and scientific activities.

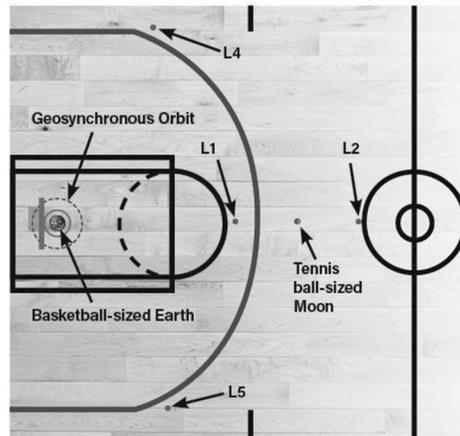
Another important aspect of the cislunar regime is its massive size. The average distance from the Earth to the Moon is 238,900 miles. To put in perspective, if the Earth were the size of a basketball placed directly under one hoop, the Moon would be the size of a tennis ball placed at the top of the 3-point line. In this comparison, the L4 and L5 Lagrange points would be just beyond the 3-point line roughly in line with the free-throw line. By contrast, the geocentric regime—where most satellites operate today—would be a small territory just beyond the rim.

That's why maintaining domain awareness in the cislunar regime will be so difficult. It's just a matter of sheer volume. That far from Earth, ground-based radars are far less useful; indeed, most existing space surveillance radars are useless for monitoring cislunar space. An entirely new architecture built from new technologies and models is needed to depict motion in this region to achieve situational awareness. These observations are essential to establishing and enforcing norms and standards.

The Moon poses its own unique challenges. With no appreciable atmosphere, there is nothing to block or absorb radiation. Earth's atmosphere and magnetic field protect us and our equipment from solar and cosmic radiation. On the Moon, no such protective barrier exists, so personnel and equipment must be shielded. A second lunar hazard is regolith—lunar dust—formed from billions of years of meteor impacts and interaction with charged plasma from the Sun. Unworn by atmospheric or water erosion, regolith is fine, jagged, electrostatically charged silica particles covering the entire surface of the Moon. These particles caused electrical, mechanical, and even respiratory issues during the Apollo program. Future Moon missions could spread regolith hundreds of miles across the lunar surface, contaminating scientific instruments and experiments—or even causing damage to economic or historic sites, such as the Apollo landing locations. A third lunar challenge is the Moon's extreme temperature ranges. Moving from a two-week lunar day to a two-week lunar night can see temperatures vary from 250 degrees Fahrenheit to minus 208 degrees Fahrenheit. Such an extreme range can leave materials brittle, and slash equipment life expectancy.

Building an Outside Game

To get a sense of the scale of cislunar operations, think of a basketball court: Satellites in geosynchronous orbit—22,000 miles from Earth—would be directly below the rim, while the Moon—238,900 miles away—would be at the top of the 3-point line.

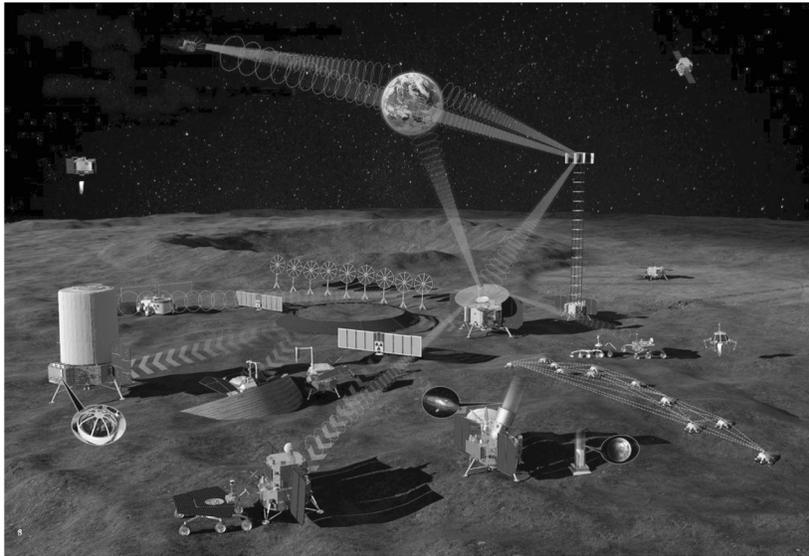


China's Approach

China's view of the Moon was made clear nearly a decade ago by Ye Peijian, then the lead for the Chinese Lunar Exploration Program. "The universe is an ocean, the Moon is the Diaoyu Islands, Mars is Huangyan Island," he said in 2015, referring to disputed islands in the Western Pacific. "If we don't go there now even though we're capable of doing so, then we will be blamed by our descendants. If others go there, then they will take over, and you won't be able to go even if you want to. This is reason enough."

Expert analysis of PLA programs and doctrine makes clear that China seeks to be the preeminent global power in space. Overtaking the United States and "establishing a commanding position in cislunar space" is a vital step toward that objective. And while China claims the United States misrepresents its peaceful objectives in space, Peijian's comparison of the Moon to the disputed islands in the Western Pacific heralds a confrontational intent. China's aggressive actions in the Pacific can be seen as laying bare its ambitions in cislunar space, as China views national power in terms of territorial control. China has repeatedly signed bilateral agreements regarding disputed territories in the Western Pacific, only to break those agreements in an effort to control more territory. The fact that the PLA also controls China's space program suggests that pattern will continue in space.

Consider how that might play out in a research scenario: If China were to establish a "scientific" station on the moon in an area rich in lunar ice, it might then require a keep-out zone to prevent others from interfering with their scientific research. Such a zone, however, could effectively commandeer the entire region and the resources in it, while denying access to other nations. Note that China is the only country to land on the far side of the Moon, and it intends a sample return mission from there in 2024. Importantly, using the gravity of the Moon, China could also conduct offensive operations against U.S. and partner space capabilities in the Earth orbit from an unobservable vantage point.



China and Russia are working together on an International Lunar Research Station near the South Pole of the Moon, joining with Iran, the United Arab Emirates, Venezuela, and others. Such research bases on the Moon could be used to try to close key regions from exploration by the U.S. and its allies. **China National Space Administration**

The Military in Cislunar Space

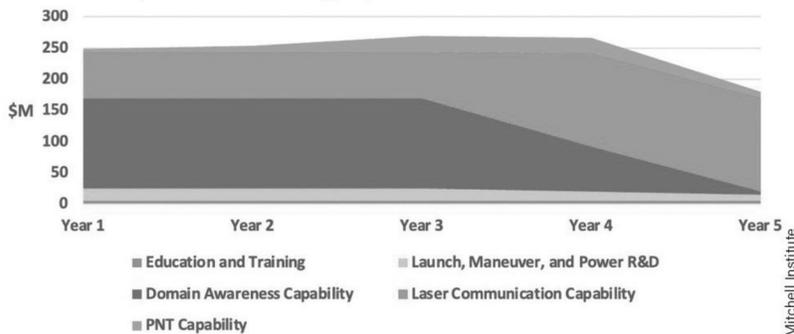
Cislunar activities are a new mission for the Space Force and Space Command and requires growth in funding and personnel. An initial budget of about \$250 million annually for five years would be sufficient to establish the cislunar infrastructure critical to the race to the Moon, accelerating delivery of needed capabilities

with the sufficient scale and effectiveness to support civil and commercial activities. It will also establish the necessary military means to secure those activities.

DOD must develop a cislunar strategy to define the military's role and relationship to civil and commercial objectives in the cislunar regime. A DOD cislunar strategy would also define the military's primary objectives as promoting a safe and stable environment, with the secondary benefits to enable or accelerate civil and commercial cislunar space development. DOD should also detail specific military objectives, such as assuring safe operations at Lagrange points or unfettered access to the lunar surface. This strategy would inform Congress in its resourcing, guidance, and oversight roles and encourage industry to invest.

Investing in Cislunar Space

Investing about \$250 million a year for five years would give the Space Force the tools it needs to compete in the cislunar regime, the Mitchell Institute estimates.



The Space Force would build on that strategy, developing the skills and understanding to properly resource cislunar missions, beginning with the math, science, and expertise required. All Guardians would benefit from some familiarization with "cislunar basics," but a small cadre must specialize in cislunar operations. This calls for about 200 cislunar-focused Guardians, to be added and developed over the next five years, and to facilitate the rapid transition of new capabilities from research to operations. They would be divided into four roughly equal lines of effort: supporting ongoing R&D efforts, acquiring and fielding capabilities, conducting operations, and training and staff assignments.

DOD must also develop new doctrine, concepts of operations (CONOPS), and requirements. Like the DOD cislunar strategy, new and/or updated doctrine, CONOPS, and requirements should include direct support to civil and commercial activities along with unique military requirements. Additionally, new requirements for navigation, maneuverability, and communication data rates will also be necessary to establish the needed cislunar infrastructure. CONOPS for achieving domain awareness or the exchange of information among military, civil, and commercial entities will advance transparency and cooperation. Within this scope of doctrine, CONOPS, and requirements, U.S. Space Command can identify how they will attribute potentially harmful or threatening behavior to promote stability and preserve interests.

To date, the Defense Advanced Research Projects Agency and the Air Force Research Laboratory have made the most notable DOD investments in this area. Early USSF participation in these efforts, and additional attention from the USSF in key areas will increase the probability of successful transition to operational capabilities.



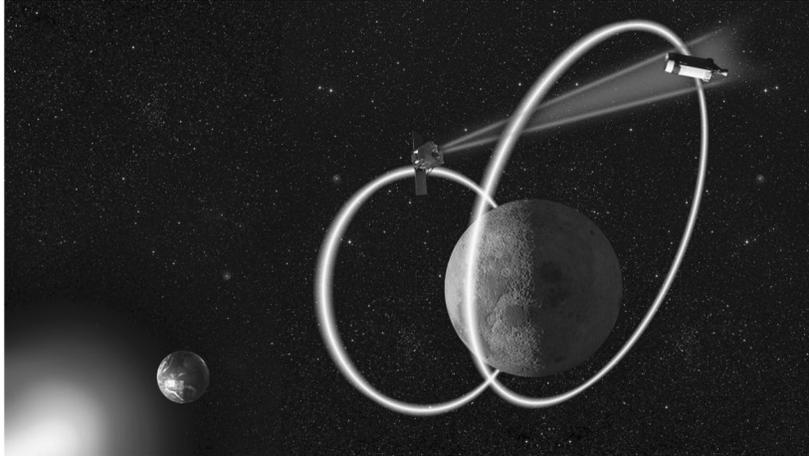
The Space Force should develop a cadre of Guardians steeped in math, science, and expertise in cislunar space. This should start with a familiarization of “cislunar basics” for all Guardians, move to an expanded training regimen for a group of Guardians “minoring” in cislunar, and conclude with a small set of Guardians with a deep understanding or “majoring” in cislunar. *Tiana Williams/USSF*

Domain Awareness

AFRL’s Oracle program will be vital to monitoring the vast cislunar regime and key areas of interest such as Lagrange points and transfer orbits. Unfortunately, due to its complexity and funding challenges, AFRL recently announced a delay in the Oracle program from a 2025 to a 2027 launch, reducing domain awareness for some 100 missions to the Moon planned in the next seven years and delaying the establishment of a robust domain awareness infrastructure for the coming decades. This delay drives risk at a time when adversary actions in this realm call for enhanced situational awareness.

High-Speed Communication

Assured, high bandwidth communication is another major infrastructure challenge DOD should tackle. Existing communication networks struggle to support the current mission load and will not be able to support the increased capacity required for the Artemis Accord’s purposes. Laser communication seems an ideal choice because it can be used for high-capacity data transfers. But this won’t be easy. The vast distances of the cislunar regime will require precise pointing accuracy to establish the links. The new network must also overcome challenges related to the relative positions and orientations of the Earth, Moon, and Sun, which will create eclipse periods and solar exclusions that necessitate multiple paths to assure uninterrupted communication. A series of relay satellites at Lagrange points, in lunar orbit, and in geosynchronous orbit will likely be necessary to meet the expected demand. A clear example of the viability of this approach is the recent achievement of a successful test message across nearly 10 million miles by the Deep Space Optical Communications (DSOC) payload aboard the NASA Psyche spacecraft.



An Air Force Research Laboratory Oracle spacecraft, shown in a conceptual illustration, would observe the region near the Moon and potentially beyond. AFRL

Position, Navigation, and Timing

Assured position, navigation, and timing (PNT) for the cislunar regime is another area requiring R&D and the establishment of standards. Leveraging its experience with GPS, the USSF is in an ideal position to lead and shape this area. Ongoing commercial, civil, and international efforts would benefit from the unifying voice of the USSF to establish a cislunar PNT standard. This will require reviewing existing and proposed methods as well as additional research to ensure operational requirements and interoperability among Artemis Accord partner nations meet actual needs.

Propulsion and Maneuverability

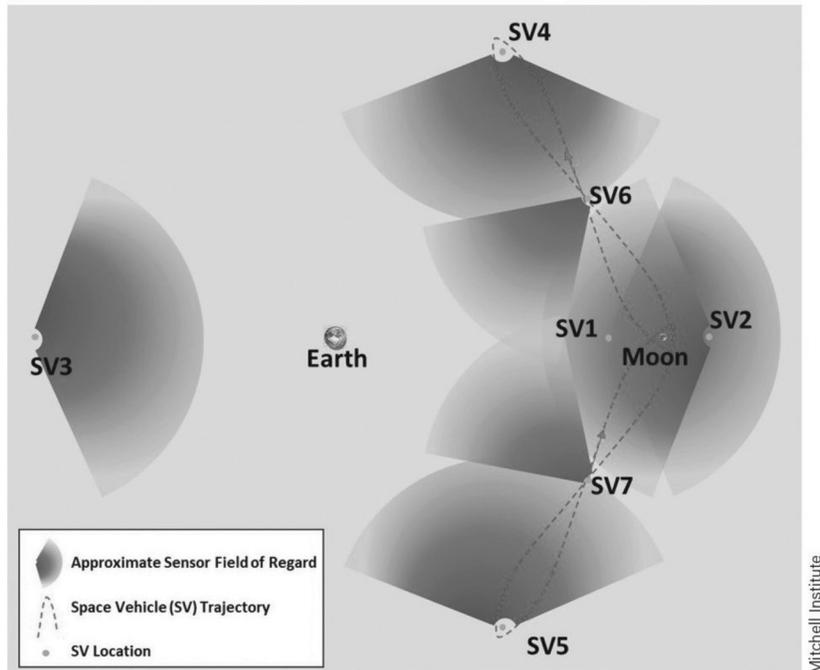
Given the longer travel distances and challenges required to lift spacecraft higher out of Earth's gravity well into the cislunar regime, it will be necessary to field vehicles with considerable propulsion and maneuverability. Like the Navy's transition to nuclear powered submarines and aircraft carriers, nuclear propulsion will likely be a critical enabler to empower future USSF cislunar operations. DARPA's DRACO is a good example of research into nuclear propulsion for cislunar. Because of the criticality of both rapid and efficient maneuver, an additional research effort into nuclear propulsion may be necessary to assure the delivery of viable nuclear propulsion options for future decision-makers. This will also reduce the risk of being tied to a single vendor or supply chain.

Power Generation and Distribution

Power generation and distribution will be another critical enabler for future cislunar activities. The ability to provide uninterrupted power to scientific, economic, or life-sustaining equipment will be indispensable. Options from solar to nuclear power are worth exploring. AFRL's Joint Emergent Technology Supplying On-orbit Nuclear Power (JETSON) is a good example of an effort exploring alternative spacecraft power generation. The DOD must also consider other novel forms of power distribution. For example, the concept of beaming power to remote users will be instrumental in supporting a variety of cislunar missions. This could come from a solar-or nuclear-powered spacecraft that could beam power to a rover operating in the two-week lunar night or from a lunar surface station to a spacecraft in orbit around the Moon.

Eyes on the Prize

To ensure full situational awareness in the cislunar region, the Space Force would need sensors aboard space vehicles with wide fields of regard.



Lunar Surface Launch and Landing

Finally, USSF and other DOD entities will need to deliver equipment, supplies, and astronauts to the lunar surface while limiting the spread of harmful regolith. Realizing these goals requires new and responsible methods to land on and launch from the Moon. One potential option is the creation of launch and landing pads such that rocket thrust is not directed at loose surface rock and dust. Another possibility could employ a tether from the lunar surface as an elevator to move payloads down to and up from the Moon. A third option, specific to launch, could be an electromagnetic rail system. Similar systems are already in use today on aircraft carriers and roller coasters. On the Moon, a system could propel a payload to a predetermined altitude off the lunar surface so that once rocket motors or attitude thrusters engage, they will not dislodge regolith.

Field Operational Capabilities

As technologies mature in the areas previously described, the USSF must rapidly transition to the acquisition and fielding of operational capabilities to present to U.S. Space Command for employment and synchronization with civil and commercial efforts. It will be important for the government and industry to maintain the expertise and talent generated during R&D efforts to streamline the transition and prevent harmful delays due to workforce loss. Early decisions on architecture and steady, consistent funding are required to realize this vision.

Consider that Oracle or an Oracle-like system is intended to be a main element of the overall cislunar domain awareness architecture; it will likely require seven vehicles—one at each of the five Lagrange points and two transiting between L4 and L5 locations and the Moon. Deciding quickly and building it into the USSF planning, programming, and budgeting process early will increase the likelihood of fielding the capability before it is too late to support upcoming civil and commercial missions.

Conclusion

The window to make meaningful contributions in the race to the Moon and cislunar region is closing rapidly. It is time to act now. This involves Congress, the Space Force, Space Command, international partners, and civil actors seeking to operate in space. The prospects of ceding the advantage to an authoritarian and territorially minded Chinese and Russian program would create an even greater disadvantage—one increasingly difficult for the United States to overcome.

Early additive investment by Congress to the Space Force will enable the development of capabilities, which will accelerate the civil and commercial use of the cislunar regime and enable the establishment of the desired norms of cooperation, transparency, and responsible behavior for the Moon, cislunar regime, and beyond.

Senator MORAN. Gentlemen, thank you very much for your presence here today. All of you have served our country. Mr. Gold and Mr. Bridenstine, Lieutenant General.

Mr. Cutler, you served the U.S. Senate as part of our staff in Commerce, Justice, Science, and I thank you all for the knowledge that you bring forward to us today.

I want to start first with the appropriations process, and Mr. Gold, maybe Mr. Bridenstine, or others would care to comment. I am worried that once again we will end up in a Continuing Resolution. I am worried that Commerce, Justice, Science is stalled, and I would welcome your efforts in the work that you now do to make certain that is not the case by encouraging support from all of my colleagues. But I would like to have you tell me what you see occurring, good and/or bad, from the passage of the Commerce, Justice, Science bill, particularly as it relates to the funding of NASA? Mr. Bridenstine.

Mr. BRIDENSTINE. So, first of all, I think it is important that to the extent that we have a CR it is better than a shutdown, and I think we all understand that. But a CR is also, it's stunning to me that people are now advocating for CRs. I want to be clear, we need to be advocating for appropriations, because ultimately technology is changing, capabilities are changing, and we need to be able to change programs commensurate with the times and not just fund things the way they used to be. Because then we buy obsolete things, and we do not buy the right things.

So 100 percent we need to do appropriations. I do worry that when we think about how we get NASA funded, the reconciliation bill went a long way to supporting human space flight. But there are a lot of other parts of NASA that are critically important. And I would say the Science Mission Directorate largely is not partisan. It is not political. There is a lot of bipartisan consensus around it.

The gentleman behind me, Bill Nye, he does not like my politics. You are probably aware of this. But I will also tell you that he and I agree strongly that we need planetary defense, we need the ability to look out in space and see large objects that could really hit Earth and do it damage. And not only that but we need to be able to intercept those, if necessary. And that is what our space program is capable of doing. That is an element of the Science Mission Directorate inside NASA, and it needs to be funded.

But all this capability largely comes from our ability to do planetary science. When we go to Mars, and we land on Mars, and we go to every planet in the solar system, these are unique capabilities that only this Nation can and has done, every planet in the solar

system. And beyond that we have got missions to the sun for heliophysics, and we have got astrophysics.

You know, I got beat up in this Committee, Senator, a lot over the James Webb Space Telescope, probably because of this guy down here on the end, Mr. Cutler. But I will also tell you that now that it is in space, everybody knows that it sets America apart from the rest of the world by 50 years when it comes to physics. Like that is the impact, 50 years when it comes to physics.

People say, "Well, why do we need to look at the stars anyway?" There is a great story I like to tell about Einstein and his understanding of time-space continuum, which ultimately is critical for how we use GPS today. Basic science resulted in us understanding time and space in a way that we otherwise wouldn't, and it enables GPS to function. That is the type of science that we get from NASA, and that is the type of capability—James Webb, we are going to learn things about things like dark matter, which I hate to even use that term, because nobody really understands it or knows what it is. But dark energy and all these different capabilities, we are learning things that have never been discovered before, and it sets us apart.

Senator MORAN. Thank you. A couple of observations. The Webb came close to being terminated for lack of progress, and the decision was made to continue.

Mr. BRIDENSTINE. Thank you.

Senator MORAN. And it seems well worth the difficulties that we went through.

Second, I have not said this publicly, but I tend to vote against a CR, which would mean a shutdown, and I have said this in previous years. We have gotten to the point in which it is easier—as long as it is easier to do a CR than to do appropriation bills, we apparently are not going to do them. And it is a mistake for this Congress to get in the habit of continuing resolutions, and unless there is a consequence we are going to do them every year.

So my hope is that I will have colleagues who join me in the effort to make sure the appropriations process does not end its early time, end its time early in this 2025 session.

A couple of other things that I want to ask before I turn it over to my Democratic colleague, Mr. Luján. Let me make sure, because a couple of my questions have now been answered. You have talked so long, Mr. Bridenstine, that I am running out of time.

Mr. BRIDENSTINE. It happens. Sorry.

Senator MORAN. And I am surprised that you have never served in the U.S. Senate.

General Shaw, in your testimony you speak to the necessity of establishing a grand strategy, of which the Chinese have already adopted, to, quote, "unify and synergize our national efforts across civil, commercial, and national security activities," and that we risk losing our domination in space without one. What are the pillars of a successful grand strategy capable of beating the Chinese in space? And it is also important that we concentrate time and energies and effort in knowing what follows once we get back to the Moon, and our long-term goals, what they should be? How does the strategy deal with getting us back to the Moon and then also the long-term strategy of what happens next?

General SHAW. So I would think that if, in the formulation of such a strategy, probably the overarching objectives extend well beyond us returning to the Moon. It is about what do we want to accomplish in this century in the Earth-Moon system and beyond, for the benefit of the Nation. And those are not going to be solely exploration objections. They are going to be about economic growth and about the appropriate security framework to ensure that we can set the conditions for that economic success, against all of the forces that this panel has already talked about and against the additional challenges we face if China gets there first and starts to establish the ground rules, almost literally, on the surface of the Moon.

So I say that if we think of it, that strategy has to be something that now establishes an architecture and a framework that lasts to the end of this century and beyond. That has to involve all of the elements of national power and all of those key pieces I mentioned in progress in any domain—exploration, economic growth, and security measures.

We do not really do that today with regard to space. We do it sometimes by accident, but it is never by design. And I would love to see us approach that from a national perspective by design. And then, as you lay out the objectives and subobjectives and you have now identified the ways and means to achieve those objectives, assigning those to the appropriate part of our nation, not necessarily our government, but maybe we rely on industry or commercial to help with some of those, or the scientific community, to help with some of those objectives. I just lay out that framework for you, Senators, something that does not really exist today that could help us.

The Chinese do have that kind of framework. They have exactly that kind of framework. And that is what is enabling them to continue to meet their milestones and goals that they have put out. And by the way, they are amazingly consistent. They predict what they are going to do, they say what they are going to do, and then they do what they said they were going to do. We should actually use that to our advantage, to really kind of understand how that is going to lay out.

So I hope I have answered your question, but that is how I would approach such a strategy, and looking at it long-term and how we can bring all of the Nation to bear on that.

Senator MORAN. General, I appreciate your answer, and I have run out of time. But in the meantime, while we develop that strategy that we should already have and we implement it and we follow it, I worry about what happens to our supply chain as we provide such uncertainty in today's world, the current problems. And that supply chain across the country is really the way that we do get back to the Moon and the way that we continue our efforts. So a lot of long-term and short-term concerns.

Senator Luján. I recognize you. Oh, Senator Peters has joined us. Senator Peters.

**STATEMENT OF HON. GARY PETERS,
U.S. SENATOR FROM MICHIGAN**

Senator PETERS. Thank you, Mr. Chairman. Mr. Cutler, thank you for being here today. Programs and contracts like those in the

Artemis support thousands of jobs across the U.S. manufacturing supply chain. I am proud that Michigan is actually one of the top 10 states in aerospace manufacturing. It is home to over 600 aerospace-related companies, and we are looking to that to grow considerably in the years ahead.

It is estimated that the Moon to Mars activities have generated over \$20 billion of economic output nationwide. However, the President's budget creates uncertainty about the future, as you know, for Artemis program after the next launch. Abandoning this program or disrupting the existing project plan jeopardizes our efforts in the space race, it hinders the development of our domestic aerospace supply chain, and potentially leaves billions on the table in future economic benefit.

So my question for you, sir, is the Coalition for Deep Space Exploration has noted its commitment to supporting the inclusion of small businesses in the NASA programs. In your experience, how have NASA programs like Artemis been beneficial to the small businesses in our states and to our local economies? And what could we do to better support efforts to include more small businesses in this important supply chain?

Mr. CUTLER. Absolutely. Thank you, Senator, for the question. If you look at Artemis, just the program itself, there are 2,700 suppliers that are part of the Artemis program. That covers everything from small mom-and-pop shops making valves, nuts, washers, all the way up to big integrators.

We cannot have this program without small businesses. They absolutely are critical. And if you think about it, these missions, they need every single piece to work. It is common to hear something like you need a million things to go right for a mission to be accomplished. You just need one to go wrong. That stems all the way up and down the supply chain, and it starts with small businesses. They are making those initial components that make Artemis possible. So absolutely critical on the small business side.

And we talked about this a little bit with Senator Moran when we talked about CRs. The instability that comes from uncertain funding, from not knowing if we are going to shut down, continuing resolution, are we going to continue the program after Artemis III, Orion? All of these things insert instability into a business' understanding. And when that happens, maybe these larger companies can weather that sort of things. Small businesses, that is hard.

And I am with the Coalition. It is a small outfit. We do not have a massive staff. And essentially I run a small business. I understand what these small guys do. They are busy. If they are working, that is their life. It is their livelihood. It is the livelihood of their workers. And if we are not doing things to help them—

Senator PETERS. I appreciate that.

Mr. CUTLER.—as well.

Senator PETERS. Good. Thank you.

Mr. CUTLER. One of the things we have done from the small business side, from the Coalition, we have brought in some of the prime contractors. We have had them talk to our members, our Coalition, small businesses. What can they do?

Senator PETERS. Thank you, Mr. Cutler. Thank you. So we want to continue to focus on this. There is no question about it.

Mr. Bridenstine, it is great to see you here today. It was certainly a pleasure to work with you in your previous capacity as NASA Administrator. And as you are well aware, in 2020, the President signed the PROSWIFT Act into law. I authored this bipartisan legislation to strengthen the Nation's ability to predict severe space weather events and mitigate the harmful events. And I appreciate you championing that with me. You were very helpful in getting that bill across the finish line, so thank you.

As you know, a space weather event can have implications for power systems, for GPS, other assets in low Earth orbit. And on Monday, the National Weather Service Space Weather Prediction Center actually just recently issued a watch for a potential geomagnetic storm, as you are aware. Continued research is needed to strengthen our space weather prediction capabilities to ensure that we can have these accurate warnings. Unfortunately, the President's budget includes cuts to this funding that could jeopardize these efforts and could have major implications for those communications systems, in particular.

So my question for you, sir, is can you speak to how NASA's science missions like the Space Weather Program play a critical role in our everyday lives? This is non-political. This is straightforward. Why do we need to make sure there is funding for space weather prediction?

Mr. BRIDENSTINE. There are a lot of different reasons to do it. Just from a pure human space flight perspective, when we start putting NASA astronauts on the other side of the Van Allen radiation belt in orbit around the Moon, on the surface of the Moon, those astronauts are in jeopardy of things like a solar flare hitting them or a coronal mass ejection, which would be, of course, even more devastating. All of that radiation environment that the astronauts are exposed to would be devastating. In fact, if you go back to Apollo 11, Neil Armstrong and Buzz Aldrin narrowly missed being hit with a solar flare that could have been devastating for their lives.

So we did not know what we did not know back then. Now we have the ability to learn and predict. Thank you to you for our efforts to help us with that.

But beyond that, I mean, when you think about the capabilities of our satellites in orbit, they become, in many cases, at risk from a coronal mass ejection or solar flares. So we need to be able to predict that. We need to be able to respond before. You know, it is not a lot of lead time. We are talking about a matter of maybe 8 minutes or 10 minutes to be able to respond to something like that. But the consequences of being hit with a Carrington Event, which was 100-and-some years ago now, 140 years ago or so, but if that were to happen today it would be far more devastating than even back then, because today we are so dependent on technology. And all that technology would be put at risk.

So I think it is important for us to be able to predict and respond and defend our power grid and defend our critical infrastructure, and a lot of that infrastructure, including command and control in space, including GPS, which is important for a timing signal for a whole host of different capabilities here in Earth, we have got to

be able to respond to that. And your bill, quite frankly, was right on point in helping us do that.

Senator PETERS. Great. Well, thank you for that. I am out of time, but if you look at the cost-benefit analysis, to cut the relatively small cost of the program and the cost to society if we do not have the warning is astronomical. So I appreciate your comments.

Mr. BRIDENSTINE. Literally astronomical.

Senator PETERS. Yes.

Senator MORAN. Senator Blackburn.

**STATEMENT OF HON. MARSHA BLACKBURN,
U.S. SENATOR FROM TENNESSEE**

Senator BLACKBURN. Thank you, Mr. Chairman, and thank you all for being here.

Mr. Cutler, I made some notes here. You have got 2,700 suppliers. You were noting impediments, and talked about the need for a budget, not having a CR. I would like to hear more from you in writing, if you will. You said you all are constantly looking at this. What about regulations? What about security clearances? What about test beds? What about other components? And if you will submit that to me for the record.

Mr. CUTLER. Absolutely.

Senator BLACKBURN. Thank you so much. Mr. Bridenstine, always so good to see you. I am happy to see you back up here. Let's talk about commercial space innovation and that importance, because you look at where we are and you look at where China is. Is there anything that the U.S. should do immediately that we, in Congress, should do immediately, that is going to encourage coordination among Federal, State, and commercial partners in order to advance innovation?

Mr. BRIDENSTINE. Yes, ma'am. That is a wonderful question. In keeping with the spirit of the hearing regarding the Moon, I think what we have got to be thinking about as a country is infrastructure. What is the infrastructure we can create that will encourage private investment on the Moon, around the Moon, that kind of thing? So part of that infrastructure I think would be—and Mike Gold has talked about it today extensively—is the Gateway. The Gateway is designed to be open architecture. It is designed so that the way we do power and communications and data and rendezvous and proximity operations and docking, all of that stuff is standardized so that commercial partners, if they want to build their own landing system that is compatible with it, they can. And, in fact, there are international partners that have an interest in doing that type of thing.

Senator BLACKBURN. OK. And in the 1990s, NASA and DoD did a collaboration on the X-37B. Correct?

Mr. BRIDENSTINE. Yes.

Senator BLACKBURN. Now, given that we are facing the kind of competition that we are, what about reinstating a program such as that and utilizing it?

Mr. BRIDENSTINE. I think it is a great idea. I would say we do have, NASA and DARPA have been partnered on some capabilities in space as it relates to nuclear power in space, for a lot of different

capabilities. But we need nuclear power in space for sensors, and in fact, if we are going to do directed energy from space we are going to have to have nuclear power for that. If we are thinking about Golden Dome and what the future of missile defense looks like.

Senator BLACKBURN. Well Gold Dome, Lunar landers, you know, those are things—I think maybe we need to think differently and revisit some ideas that have worked.

Mr. BRIDENSTINE. Yes.

Senator BLACKBURN. And may open new opportunities. Tennessee had a Space Grant Consortium. They did this with NASA. Did it 27 years ago. And it was there to promote space and science education throughout the state. And 15 colleges and universities, two not-for-profit organizations, and today the UT Space Institute is one of the leading hypersonic workforce programs in the country, and we love the work that they are doing around space force, that they are doing around hypersonics and the testing that can be done at Arnold Engineering. And we think this is something that is beneficial, and it encourages that interdisciplinary training that needs to take place.

So talk a little bit about related items of education and how that affects some of the workforce that could go into some of these programs like the program with DoD and NASA?

Mr. BRIDENSTINE. One hundred percent. So when you are thinking about NASA projects, we find that when we have a university as a leader of a project, you will have students working side by side with professional engineers in a way that you see a collaboration that is really beneficial to the students. I would also say that in a university environment you have the scientists side by side with the engineers. So they are making trades in the development of a program early.

A lot of times you find that, you know, you start going down an engineering path and the science doesn't work, and it gets too late in the program, and it results in delays and cost overruns and everything else. But in a university environment where you have got the scientists and the engineers working together side by side, and you have got students in the mix, learning alongside—

Senator BLACKBURN. And you have students who are not afraid to fail.

Mr. BRIDENSTINE. That is it.

Senator BLACKBURN. They are looking for opportunities to try new concepts. And I think that is why UT's program has been so successful.

Thank you. Thank you, Mr. Chairman.

Mr. BRIDENSTINE. Senator, I would also say if you looked at the university-led missions, overwhelmingly they are on budget and on schedule. And that is not always the case outside of universities.

Senator SHEEHY [presiding]. Senator Rosen.

**STATEMENT OF HON. JACKY ROSEN,
U.S. SENATOR FROM NEVADA**

Senator ROSEN. Thank you, Mr. Chairman. Thank you to all of our witnesses for being here today. Quite a great conversation. But I have real concerns over budget cuts, because we are talking about

research, amazing research. Scientists not being afraid to fail—that is how science happens, right. Sometimes a failure leads you to a positive result down the line. They tell you something.

And so we have seen how NASA's investments in research and innovation, STEM education, they fuel our economy, they strengthen our national security, and actually they are inspirational as they inspire the next generation of scientists, engineers, dreamers and thinkers, and all of those things.

We know what the space program has done for us through the decades. So I am concerned about the President's proposed budget cuts to key programs that have long delivered value, well, right here on terra firma, right here on Earth, specifically aeronautics research at the Armstrong Flight Research Center, ISS payload operations at Marshall Space Flight Center, and science missions at Goddard Space Flight Center, just to name a few.

So Administrator Bridenstine, can you talk about the potential impacts of proposed cuts to just some of these programs I have mentioned, particularly as we are building on what everyone has been asking about, innovation, scientific leadership, leadership in general, our ability to respond to these challenges, economic competitiveness, aerospace advancement, climate, and national security?

Mr. BRIDENSTINE. Yes. So I think it is important when we think about, you know, when we think about NASA and the budget that it has, and you think about the size of the U.S. budget. We are talking about now an agency that has less than one-third of 1 percent of the Federal budget. And by the way, if you go back to Apollo, it was somewhere between 4 and 5 percent. So we are significantly smaller as a percentage of the Federal Government than we were back in the Apollo era.

All that being said, not all of that is because of NASA cuts. I want to be clear. A lot of that is because of the growth of government in other areas. And I certainly understand we have a huge deficit problem, and we have got a debt problem, and I know that the President is focused like a laser on trying to get control over that. And by the way, I think everybody bipartisan understands that we have got to get control of it.

I would also say it is really hard to balance the budget when you are talking about cutting a few billion dollars from an agency that has less than one-third of 1 percent of the Federal Government.

Senator ROSEN. But I would argue with you saying that the economic development, the inspiration—I am a child of the 1960s and 1970s. I watched them walk on the Moon. I know people that went into careers because of what they saw. And that still happens today. So I would argue that there is probably a pretty good return on the investment.

But we have a lot of other questions so I'm going to just try to move on in my two minutes, because I want to ask you again about the future this time of space station. Because the request for proposals for Phase II of the Commercial Low Earth Orbit Development Program is expected to define NASA's level of investment and commitment, awarding contracts to two or more commercial providers to ensure redundancy and competition for services. That is

essential for driving innovation. Competition drives innovation and economic growth.

So given your previous role at NASA again, Administrator, can you speak about the critical need for these providers to be operational before the ISS deorbits? We cannot wait to have nothing up there and then hope we are going to get something there. So how do we ensure the timely development and deployment of these systems?

Mr. BRIDENSTINE. I think it is important to note that we need to have space stations that can, in effect, replace the International Space Station. When I say that I mean space stations that are fully mission capable and have a permanent human presence in space. The capabilities and technologies that come from human space flight are significant. We have talked about some of them today when we think about pharmaceutical development to treat diseases that have never been treatable before, regenerative medicine, the ability to print in 3D human tissue to grow in 3D human tissue. All of these capabilities, if we do not stay in front of it our greatest competitor, China, will, and our international partners will join them in that effort.

So it is important for us to have fully mission capable space stations that can replace the International Space Station. And I would also say when it comes to advanced materials, whether we are talking about semiconductors or we are talking about hypersonics, microgravity is critical to all of these capabilities, and we are at risk if we don't have a fully mission capable system. If we do not have a permanent human presence in space, we are at risk of losing that to our greatest competitor.

Mr. GOLD. And Senator, if I may, it is not only—you make an excellent point—that we avoid the gap, but we must have orbital capabilities that are at least equal to the Chinese. We have to avoid the gap and make sure that we are equal or superior in LEO, for all the reasons Jim just mentioned.

Senator ROSEN. Well, thank you. I think investing in innovation research, public-private partnerships is really important. Thank you for your time today.

Senator SHEEHY. Mr. Bridenstine, is that a Bill Nye-approved beverage you have there? Diet Mountain Dew—that is a first.

Mr. BRIDENSTINE. I am guessing not.

Senator SHEEHY. He is shaking his head. I grew up on Bill Nye. I am a child of the 1990s, so I grew up on Bill Nye. Senator Young.

**STATEMENT OF HON. TODD YOUNG,
U.S. SENATOR FROM INDIANA**

Senator YOUNG. Thank you, Chairman. Thanks for our witnesses for being here, and good to see you again, Congressman.

As many of you know, Indiana has deep roots within our Nation's space exploration history. Purdue University likes to call itself, I think fairly, the "cradle of astronauts." I was up there actually over the weekend with some family members, and you see a lot of banners. They advertise that to those who visit the community. They inspire many of us, including the students, with their 27 astronaut alumni, including Neil Armstrong, the first man on the Moon, who was a Boilermaker.

So this is, of course, an effort to boast about my state, but it is also to highlight the opportunities, I think, that many U.S. universities provide to our young scientists and our engineers.

So as we look to reauthorize NASA, partially authorized through the CHIPS and Science Act, I am proud to say, just a few years ago, I believe it is crucial to focus on implementing strategic investments in research to not only secure our STEM pipeline, but to maintain a competitive edge in scientific research and development, which will eventually lead to commercialization and deployment of new technologies to bolster our space exploration.

Mr. Gold, thank you for your testimony and for highlighting the groundbreaking microgravity research that Redwire is advancing aboard the International Space Station. This pioneering work, the world should know, is anchored in Greenville, Indiana. It not only strengthens our state's economy but it also underscores the state of Indiana's growing leadership in space innovation.

Mr. Gold, could you speak to how space and biotech, also something associated increasingly with the state of Indiana, are converging, and share your vision for the future of microgravity research in Indiana and beyond?

Mr. GOLD. Thank you so much, Senator. I believe you have been to our Greenville facility, and even launches, and thank you for your support.

We are at a point where microgravity and pharmaceuticals are coming together in a way that will transform both fields. In my opening comments I talked about how we are printing meniscuses, how we are printing live cardiovascular tissue, bringing it back to the ISS still live. At this most recent launch to the ISS, just a week ago, we launched liver cells, and we will print with liver cells. Drink all you want—Redwire has got you covered. We will get you a new liver.

[Laughter.]

Mr. GOLD. Enjoy some of that good Kentucky bourbon.

But think about it. I mean, we have all had friends who are on the organ donor list probably, who have suffered or died. Not only can we change that paradigm, but because these organs would be grown with your own stem cells, we could avoid the painful and expensive anti-rejection therapies.

Additionally, we have now flown 32 pillbox systems. These are growing seed crystals for drugs. Seed crystals are like a sourdough starter kit, that we just need to bring down from space a thimbleful of these seed crystals, and then they lead to drugs that, because in microgravity the seed crystals form larger, more uniform. We get new versions of drugs, better efficacy, better longevity, and fewer side effects.

We partnered with Eli Lilly. We flew a version of insulin. Lilly said those were the prettiest crystals that they have ever seen. This revolution is happening, so let's not turn around now and snatch defeat from the jaws of victory.

We are about to move into an even larger facility in Indiana, so I appreciate the support and reassure you that the road to space goes through Southern Indiana.

Senator YOUNG. Well, that is great. It is a road with many arteries, so let me sort of end by being expansive here and inclusive.

I think your testimony here today, Mr. Gold, illustrates how parts of our country that people would not perhaps associate as important components to the space economy are ready to go. And they are on the cusp of achieving some amazing achievements, scientifically, engineering wise, and by extension, that will benefit the economies, regional economies, all around the country.

These continued scientific investments through the CHIPS and Science Act, by reauthorizing NASA, et cetera, are critical. And I say that to a lot of my colleagues, but I also want the Administration to know it is OK to have a pause on research funding. But unless they present an alternative plan to fund some of these research projects that collectively benefit all of us, and are not internalized into individual companies, then we are really going to be missing the boat.

I would also say, just to add here, and I know I am over my time, but we do that in the Senate, I would also say that our adversaries are not slowing down. I received this, so it may be a little choppy here, about 30 seconds before I started speaking. But a little social media post pertaining to a comment that Vladimir Putin just made. This was overheard, as I understand it, by a Chinese state media broadcaster. And evidently, Vladimir Putin, walking toward Tiananmen Square for a parade, his translator could be heard saying, in Chinese, "Biotechnology is continuously developing." The translator added, after an inaudible passage by Putin to Xi Jinping, "Human organs can be continuously transplanted. The longer you live, the younger you become. And you can even achieve immortality."

So these can seem like things that are abstract and removed from the daily lives, I know of my own citizens. But they are here and now, and we do not want our adversaries to get ahead of us in these areas of science. So all of you are testifying to things that I know my constituents will find compelling and lead many of us to continue investing in these critical areas. So, I thank you.

Mr. GOLD. I appreciate it, Senator. If I could make a plea. We will lose the momentum, if not these capabilities entirely, if we drop from 4 to 3 astronauts. And we need the Senate to stay on NASA, and your excellent staff, to make sure that we realize these commercial benefits and that America never, never drops below the number of Chinese in space.

Senator YOUNG. Thank you.

Senator SHEEHY. The Senator from Colorado.

**STATEMENT OF HON. JOHN HICKENLOOPER,
U.S. SENATOR FROM COLORADO**

Senator HICKENLOOPER. Thank you, Mr. Chair, and thank all of you. This is really a stellar panel, if I can be so graceless.

General Shaw, you are a former Deputy Commander of SPACECOM, and you know better than most the threat that China poses to U.S. national security, and our interests in space especially. China's capabilities in this domain are accelerating rapidly, the result of which you noted in your testimony, a complete fusion of civil, commercial, and national security expertise.

What is your assessment of the threat from China over the next 4 to 5 years, especially in light of their, as we just heard, the cozying up of Russia to China?

General SHAW. Thank you, Senator. First, let me, just from a purely military perspective, what we have seen China do over basically the last couple of decades, is look at what we have done in space for our warfighters. And I am fond of saying that our joint warfighters today rely more on space than they did yesterday, and they will rely more on it tomorrow than they do today. That is a curve that continues to move upward. China has observed that. That is exactly why they have developed capabilities to deprive us of our space assets, and why they have built and deployed space weapons.

But they have also built their own space capabilities mirroring ours, to enable their warfighting too. So this has been a progression, an emulation, and a surge. And I recommend that the Committee, if they are not regularly getting briefings from the U.S. Space Force S2 on China's capabilities that it might be helpful to get that classified briefing on what they are doing, from a military perspective.

Senator HICKENLOOPER. We are getting that. It is truly alarming. And I am sure, as you saw yesterday, the Administration announced its intention to relocate U.S. Space Command, which is fully operational now in Colorado to Alabama, citing political factors such as mail-in voting, and some other things. The DoD inspector general said in a report earlier this year that it will take 3 to 4 years for the same mission critical systems to be established in Alabama that our warfighters rely on every day in Colorado.

Given the threat picture you just shared, what is your assessment of the impact to readiness—we are full operational capability right now—to readiness that this delay would have or could have during such a critical geopolitical window?

General SHAW. I would just say I know Troy Meink pretty well. He is the Secretary of the Air Force, and he was probably very closely involved in the decision. And I have known him to be a good thinker on those topics, and he probably made a good recommendation to the President.

Senator HICKENLOOPER. We will see. Switching to space debris, Mr. Bridenstine, let me ask you, obviously you know today that we have got over a million space debris objects over 1 centimeter, most of them traveling hundreds of thousands of miles per hour, can do severe damage to aircraft, satellites, at that speed almost anything. The Space Station has had to conduct 27 debris avoidance maneuvers since 1999. Astronauts had to take emergency shelter as recently as June 2024, last year.

Do you believe it is a national security imperative that the United States develops and demonstrate technology that can remediate space debris?

Mr. BRIDENSTINE. Remediation, boy, that is really hard. I think it is a capability that, in some cases, makes sense, in other cases maybe not. You mentioned items that are 1 centimeter and bigger. When you are talking about objects that are 1 centimeter and bigger, the cost of going up to space to remediate or bring down some-

thing like that, it is extraordinarily expensive for the return that you get.

If we can see it and we can track it, remediation probably is not the right approach. But the alternative is if you can't see it and you can't track it, you wouldn't know that you need to remediate it. So it is a double-edged sword here.

I would tell you the cost is really expensive. I would say what we have got to do, instead of remediate we have got to mitigate. We have got to make sure we are not putting more debris out there.

Senator HICKENLOOPER. That too. I agree with that.

Mr. BRIDENSTINE. And then I also think we have got to be able to have space situational awareness, space domain awareness, and we have got to be able to maneuver. I think it is critically important that we increase our ability to maneuver. And I will also say, here is the challenge that we face. We are putting so many satellites into the same orbit. We are talking about tens of thousands of satellites going into one orbit, from one company and one country. Well, you start adding another company that wants to do it, and another company that wants to do it, and another company that wants to do it, and then you start talking about, well, Europe wants to have their own LEO, low Earth orbit mega-constellation, and China wants to have its own low Earth orbit mega-constellation, and each of them have numerous projects. There is no organizational system around it that will prevent us from getting to what eventually is the Kessler Syndrome.

Senator HICKENLOOPER. Right. No, I got that.

Mr. Cutler, I have a question for you, as well, but I will put that off into the written because I am out of time. But I do think that some of the stuff, like the MAVEN mission out of the University of Colorado Laboratory for Atmospheric and Space Physics, collecting essential data about atmosphere on Mars and really getting into that deep research, there are a lot of things that we need to discuss about that. I will put that into the written.

Mr. GOLD. Let me just say, Senator, Redwire is happy to be in Longmont and Littleton, Colorado.

Senator HICKENLOOPER. Thank you.

**STATEMENT OF HON. TIM SHEEHY,
U.S. SENATOR FROM MONTANA**

Senator SHEEHY. Well, it is my turn, and I actually wanted to be an astronaut as a kid. I went to the Naval Academy, which has produced more astronauts than anyone else. Unfortunately, I was not smart enough so I became a Senator instead, which I fit in perfectly now here.

Mr. Bridenstine, you made a comment earlier—we didn't know what we didn't know in the 1960s. We did not know a lot of what we face as far as just the physics and science of the universe literally that we were operating in. And, you know, it was just about 8 years from the time the first flight from Alan Shepard to when Neil Armstrong set foot on the Moon. And in 8 years we went from zero space flight capability to literally sending humans to another planetary body, and bringing them back safely, which, as you remember, was Kennedy's initial writ when he laid out that vision.

And, you know, right now, this smartphone I carry, and you all, I am sure, have in your pocket, has 10,000 times the computing power of what the Apollo 5 rocket had on board as far as its guidance systems and ability to determine its navigation routes. We have computing capabilities and knowledge of the cosmos that far outweigh anything we thought we even could ever know in the 1960s.

And yet we look at what our capabilities are now, and other than some bright spots, like a James Webb telescope and others, for the most part we are far less capable at star voyaging today as a nation than we were 50 years ago. And for a decade we were paying the Russians taxi fare to send our own astronauts into space. I mean, if you went back and told Reagan and Kennedy that, “Hey, in 50 years we are going to be paying the Soviet Union \$60 million a seat to take American astronauts to outer space,” they would laugh in your face. There is no way they would believe you.

And as a lifelong space enthusiast and someone who truly believes that not just our national security but our economic security, our fundamental stability as a nation does depend on our ability to continue to lead in space, I am very, very concerned about what the next decade looks like. And I am very concerned that the bureaucracy of NASA, of which I love NASA and I am supportive, but we have to be honest with ourselves, is the bureaucracy of NASA positioned to give us space dominance in the 21st century.

Just like we are seeing in the DoD right now. Our legacy Industrial Age acquisition infrastructure is failing to keep pace with China. The build ships 200 times faster than we do. The Chinese are putting more satellites into space every day than we are every month. We are looking at the ability for us to innovate, iterate, and deploy technologies that we are just not keeping up with the rest of the world.

So as we look at systems like SLS, which I agree we need, we look at Orion, we look at the SpaceLiner, and we say to ourselves, are our acquisition engineering and development processes within NASA up to the task?

Meanwhile, we look across the street at SpaceX, and yes, NASA is involved in that, but that is a private enterprise that is, frankly, innovating at astounding rates. Starship’s flight last week was a wonder to watch and incredible to see what is happening there.

So assuming we all agree, which it sounds like we do, that we want America to lead the next space race, is NASA, as it is currently configured—obviously it does not have a leader right now; hopefully soon it does—but is NASA, as it is currently configured, ready to lead that race, or do we have to rethink how America structures our space program?

Mr. BRIDENSTINE. So I would say, first of all, you covered a lot, and I think I am in agreement with primarily everything you said. I think when you think about what has hindered us from going forward, you go back to George Herbert Walker Bush. We had the Space Exploration Initiative, which was a plan to go back to the Moon and on to Mars. And then the next administration came in and canceled it. And then we had—George Herbert Walker Bush was SEI, and then George W. Bush was the Vision for Space Exploration, which was a plan to go back to the Moon and then on to

Mars. The new administration came in and canceled it. And then President Trump comes in and says, "We're going to go to the Moon and on to Mars," and for the first time the program sustained.

As I said earlier in the hearing, the architecture is challenged, significantly, in the current format. That architecture is extraordinarily complex. It, quite frankly, does not make a lot of sense. If you are trying to go first to the Moon, this time to beat China, it does not make sense to do that.

But the question is then what do we do? And I think one thing we can do is we can say, look, we are not going just to put flags and footprints on the Moon, as we did back in 1969 through 1972. What we are doing now is we are going to go forward to the Moon. Mike Gold, I think correctly, talked about the Gateway and how that could be basically our moon base around the Moon. And then we can have commercial and international partners join that moon base to be able to have access anywhere on the surface of the Moon, at any time we want. We can go to the North Pole. We can go to the South Pole. We can go to the equatorial regions. Wherever the most valuable spots on the Moon are that we need to go, we can go.

But we are building infrastructure, and we are allowing private capital to go forward and build all of the things that we can do on the surface, and that means extract resources, whether it is platinum group metals or other precious materials, whether it is Helium-3 or water ice or other capabilities.

I think that is transformational, and it also includes a lot more private companies. It includes a lot more international partners. And it is an open architecture system where we can actually have a sustainable path that goes forward, regardless of administration.

So getting cast to and fro from one administration to the next has been very damaging over time, and that is the challenge with NASA. What we do is multi-decadal in nature, and sometimes it is multi-generational. And you can't just have it go back and forth all the time.

Senator SHEEHY. Well, I would be curious of especially your opinion, General, you know, the history of our space program, that there was a period of time where there was great tension between the Air Force and NASA as a push and pull between is it a military primacy or is it civilian? And, of course, we have always maintained that space should not be militarized. But that is a belief we hold. Other nations don't necessarily hold that outlook.

How do you see the Space Force now weaving with NASA, going forward, to energize our ability to have a significant defense presence in space?

General SHAW. Well, first I would point out our adversaries have already militarized space and developed space weapons. I would also point out that that sometimes is a lottery of progression in any domain where there are competing resources, competing economic growth, and general competition.

So I have always said, when I was in the Space Force and I will say it today, our mission is predominantly to deter such a space conflict from ever happening. And if we do that job properly maybe it would deter a broader terrestrial conflict too, by just making an adversary think they cannot achieve an objective.

As for the future, as I said in my opening statement, I do not think we ever could envision that we would do exploration, economic growth without some sort of security measures around that, for confidence, to ensure that we have transparency so that people want to invest. They are incentivized to do so in an environment that shows promise and shows security, as opposed to a Wild West scenario that might be dissuasive.

Senator SHEEHY. Well, I am over my time, but one other topic I would love to throw, and I will throw in the record, but hardening our space infrastructure, there is a perception that if it is in space, it is safe, and the reality is we are incredibly vulnerable from our communications- and navigation-based orbital infrastructure. And especially if we look at Golden Dome and space-based interceptors and space-based detection, we need to make sure we are hardening our space infrastructure, because it is pretty vulnerable.

Senator Luján is up next.

**STATEMENT OF HON. BEN RAY LUJÁN,
U.S. SENATOR FROM NEW MEXICO**

Senator LUJÁN. Thank you, Mr. Chairman. I appreciate that. I very much appreciate the conversation today. One of the concerns that I have is the President's proposed budget slashes NASA's budget to levels like back to 1961. Now, I appreciate what Chairman Moran shared, is that the current mark of the Commerce, Justice, and Science Appropriations Committee has it at level funding.

Back to a concern. This Administration has been operating in a way where they are ignoring the law and saying if they want to cut something, they are going to do it, and sue me in court. Come find me.

Now, one of the concerns that I have in that space, there has been a lot of attention brought to the incredible work that takes place at universities, K-12, STEM education, collaborations and partnerships that are strengthening America's competitiveness. We have now seen 3,800 employees that have left NASA because of the financial uncertainty, 20 percent of the agency. That does not seem helpful.

On STEM, states like New Mexico, clearly other colleagues who have spoken today, all benefit from incredible investment, to allow these collaborations that I pointed out earlier.

Now, this hearing is dedicated to the United States beating China in a space race. My questions to each of you today is, yes or no, would huge cuts to NASA and its STEM efforts harm America's ability to compete with China in the space race? Mr. Cutler.

Mr. CUTLER. Absolutely. There is no question that it will harm our capabilities. We have seen impacts already, just by proposing this budget from the President in industry, where companies are having to look at what do we do if our business goes away. And project managers are looking for other jobs. Absolutely, just from an industry perspective.

Right now, we need people working on Artemis, not working on their resumes, and that is absolutely something that should worry all of us, because if they are not doing the work for the missions to inspire those kids, where is that K-12, that STEM education, why are they going to go into this business? Why would you go into

space if you see it is not going anywhere in China, where it is happening?

Senator LUJÁN. I appreciate that. Mr. Gold, yes or no?

Mr. GOLD. Yes.

Senator LUJÁN. I appreciate that. Mr. Bridenstine.

Mr. BRIDENSTINE. No.

Senator LUJÁN. No? You can talk more, sir, if you want. If you can explain to me how you complimented one of my colleagues, two of my colleagues, with your response as to the incredible importance of collaboration with student scientists and engineers to America's competitiveness, but you do not believe that this is harmful?

Mr. BRIDENSTINE. No. What I am saying is when you think about STEM education there are different ways to approach it, and I think NASA's missions, when they partner with universities, that is a great thing to do. I think, you know, when you think about the partnership where we have got scientists and engineers working side by side, and you have got the students in the mix, I think all of that is extraordinarily beneficial. But that is also within the program itself. Does that make sense?

I do not know that NASA needs to be free.

Senator LUJÁN. No, it takes investment.

Mr. BRIDENSTINE. No, I agree with that. I am in agreement that we need to absolutely be involving students in the projects that NASA does at universities. I am in full agreement. I just think when you think about education, we have a Department of Education, and we should have them focus on—

Senator LUJÁN. For now.

Mr. BRIDENSTINE.—on education.

Senator LUJÁN. All right. General.

General SHAW. My answer is yes, and I would hope that the current cuts we are seeing are temporary, as I think one of the other members mentioned earlier this morning, and are helping us refocus on what we really need to be concentrating on in order to beat China.

Senator LUJÁN. I appreciate that, Lieutenant General. I would agree. There seems to be strong bipartisan support in all of these efforts. I appreciate that response.

Representative, during your tenure as NASA Administrator you created the suborbital crew or SubC program to leverage commercial sub-vehicle for scientific technology development. When fully implemented, what benefits will SubC provide to NASA and to the broader space economy?

Mr. BRIDENSTINE. Oh, I think that is a great question. When you talk about suborbital space flight, in general, you are really talking about microgravity. There are ways to get microgravity. We can go up a tower and we can drop an object, and you can get maybe a second or two of microgravity. Then we can put things on an airplane and put it on a parabolic trajectory, and you might be able to get 30 seconds to a minute of microgravity. Then we can go to suborbital space, and that is where I think we can have even more benefit, because you can get 4, maybe even 5 minutes or more of microgravity. And all of that enables us to do research and development on technologies and capabilities.

And then, if all that works, then you send it to the International Space Station or you send it to commercial space stations. You put all that together.

Senator LUJÁN. And just a sidebar of that, if that program was cut, how would the United States be ceding ground to China?

Mr. BRIDENSTINE. Well, I think it is important to recognize that without that program there will be a lot of development capabilities that just get canceled. And it becomes, quite frankly, more expensive, not less expensive, because now you have got to go to orbit to test things, and that is super expensive.

Senator LUJÁN. I appreciate that. Mr. Chairman, I have other questions. I will submit them into the record because of time. Thank you all for your responses today. I appreciate it. I yield back.

**STATEMENT OF HON. BERNIE MORENO,
U.S. SENATOR FROM OHIO**

Senator MORENO [presiding]. Well, thank you. So you had made Senator Cruz Captain Kirk. I will be Captain Obvious. The need to fund NASA in the One Big Beautiful Bill was something that was very important. Would any of you disagree that without that \$10 billion of funding that it would be absolutely devastating to what we just talked about all morning? All in agreement.

VOICE. In agreement.

Senator MORENO. And again, I just want to point out there was not a single Democrat that voted for that bill. I think I just want to make sure that is crystal clear on the record. So as important as we all said that is, as important as we say this is bipartisan, yet, when the bill got presented it was 100 percent of the Democrats voted against that bill.

Let me just also say that when we talk about sequencing—how do we get to the Moon, how do we get there before China—I am still the optimist. I think we can get there before China gets there. There is sequencing that has to happen. Something has to happen before something else. And if we are going to have Moon exploration, Mr. Cutler, you are going to be in Ohio next week. Sorry I will miss you there. I am sure you are going there because you are going to celebrate the massive victory of Ohio State versus Texas. But while you are celebrating that victory, talk about the importance of nuclear fission and the importance of really developing that program?

Mr. CUTLER. Well, first of all, I am sure they are still celebrating. They have got a week, so that is great.

Here is where I view nuclear fission. This Committee, this Congress has been supportive of all forms of nuclear. Like if you are looking at propulsion—NTP, electric—it something that we absolutely—if we want to open up our exploration of going beyond the Moon, going to Mars, going even farther in the universe, we need to have better propulsion. This is something that we need to be working on.

So benefits? Absolutely. There is only so much you can do with chemical propulsion. And if we want to really sit there and send ourselves out into the universe, we need to do something different. Now, you have got that surface power. You need that too, for the

Moon. Astronauts are going to plug—you go home, plug all your stuff into the wall to recharge. It is going to be the same on the Moon. You are going to need power.

But this is technology that we should be working on and through this Committee have been supporting for years, and we need to up our game on that. It needs to be worked on. It is absolutely critical.

Senator MORENO. And I saw you earlier talk about Secretary Duffy, Administrator Duffy, depending on what hat he is wearing, put some serious resources behind that.

Mr. CUTLER. Absolutely.

Senator MORENO. And where would you say is the center of excellence of nuclear fission for space power?

Mr. CUTLER. Well—

Senator MORENO. The only answer is Cleveland.

[Laughter.]

Mr. CUTLER. I know where you are going because of electric. Cleveland is where you go.

Senator MORENO. There you go. Make sure that that is highlighted in the record.

So in terms of, Lieutenant General, back to you, the coordination between the military and NASA, how important is it to us to really take that to the next level, to really get this done and to compete with China?

General SHAW. Yes, Senator, and the first I would say, the Department of Defense and NASA have always cooperated, from the very beginning. I mean, whether it was the Mercury, Gemini, Apollo missions, whether it is even, under my recent commands that I had before I left uniformed service, the Department of Defense was providing the debris situation to NASA, to make sure that the astronauts on the ISS were safe. And we actually had NASA representatives in the Operations Center at Vandenberg Space Force Base, where I was the commanding general, that watched that continuously communicating with Houston, and letting them know if a maneuver would be necessary for the ISS. And there are many, many more examples. Like I said, we have partnered in the past.

Those will only become more important as we look to put a permanent human presence in the lunar environment, as I expect that there will be parallel efforts for commercial capabilities in the lunar environment that may or may not involve humans, but they are going to do the sorts of things that some of my panel members have mentioned here before. And it is not just the lunar environment. It is the entire Earth-Moon system.

Again, you do not get economic growth without security, as well. And I do think, as the Space Force matures, in addition to all the things it needs to do today to enable terrestrial warfighters and protect our capabilities in space, it is also going to involve a mission that provides awareness of hazards, awareness of threats, and a transparency in space that enables all of these activities. We are going to see that happen. It happened in every other domain. The U.S. Navy and U.S. Coast Guard have done it from the very beginning in the maritime domain. You will see the U.S. Space Force do it in the future.

Senator MORENO. That is right. And obviously taking that to the next level is critically important.

And I will wrap up the last question with you, Mr. Bridenstine. When you were the NASA Administrator you visited a lot of places. What was your favorite place that you visited while you were NASA Administrator? There is only one answer there.

Mr. BRIDENSTINE. Cleveland.

Senator MORENO. Cleveland is the right answer. Perfect. That is good. And if you could end with us, how important is it for us to unleash the private sector? Because we talked a lot about competing with China, and certainly China is a model. It is not the model I would choose. It is not the model we would ever want to replicate. I think the advantage we have is that we have this strong, thriving private sector. How do we really integrate that to accomplish the mission that we all want?

Mr. BRIDENSTINE. I think that is a great point and a great question, and I think we have got to, as an agency, NASA needs to build infrastructure that the private sector can see how they plug in and benefit from it. And then you get these naturally forming public-private partnerships, for example, the Gateway. If they can see themselves plugging into the Gateway, they will utilize it, they will make investments to do that.

When I was at NASA we created Commercial Low Earth Orbit Destinations. Of course, that is a capability to replace the International Space Station. We created Commercial Lunar Payload Services. That is a way to get landers to the surface of the Moon. We have a commercial landing system for the Moon. I will tell you that the architecture for that is extraordinarily strained, but I think it is an important capability, and we need to have as much commercial as possible.

I will tell you that when it comes to commercial, we have got to make sure—and I said this a lot when I was at NASA—the only thing worse than a government monopoly is a private monopoly that the government is dependent on. So when we think about commercial, we have to have multiple providers that are competing against each other, on cost and innovation and safety, and each of those providers has to go get customers that are not NASA. And if they are willing to do that and capable of doing that, then we can have this very robust capability, this marketplace, that I think will be thriving. But I think we have got to be really careful about how we frame that.

Senator MORENO. I appreciate it. Sorry, Mr. Gold, I did not ask you a question, but you are the most enthusiastic witness in the history of the Commerce Committee and my time in the Senate, by the way.

Mr. GOLD. Let me be briefly enthusiastic for Cleveland, not only great nuclear but the leader in solar electric propulsion on the PPE on Gateway. So thank you for the support, Cleveland and Glenn.

Senator MORENO. There you go. And as we are working through the Commerce appropriations budget, let's make sure we keep that all at top of mind.

But I want to thank all of the witnesses for their testimony today. Senators will have until the close of business on September 10 to submit even more questions for the record, if that is possible. Because, you know, in the Senate, not everybody has made a point—points have been made, but not by everybody, is the mantra

around here. So we will see if you get more of the same questions. But the witnesses will have until the close of business September 24 to respond those questions.

And this concludes today's hearing. You guys have stamina. Two hours—fantastic. And the Committee is adjourned.

[Whereupon, at 12:42 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF CASEY DREIER, CHIEF OF SPACE POLICY,
THE PLANETARY SOCIETY

Chairman Cruz, Ranking Member Cantwell, and members of the U.S. Senate Committee on Commerce, Science, and Transportation:

The title of this hearing posits that Congress and NASA face a critical challenge from China's space ambitions. If America is engaged in a consequential space race for national prestige and strategic advantage, then the Nation cannot selectively compete. No nation can be preeminent in space while simultaneously retreating in its scientific exploration capability.

Unstrategic and Wasteful Cuts Proposed by the OMB

The White House's Office of Management and Budget, without significant consultation with Congress or NASA itself, proposed a draconian 47 percent cut to NASA's Science Mission Directorate in FY 2026, which would result in the termination of fully a third of the agency's current and future science projects. One-of-a-kind missions in deep space, the outer planets, Mars, solar physics, and Earth Science would be switched off despite still providing valuable data; NASA's pipeline of future projects would shrivel to a trickle; and without data or funding, a generation of students and early-career scientists, engineers, and innovators would be lost.

NASA's science programs positively impact every state in the union and 3 out of every 4 congressional districts. NASA missions are generative investments, demanding boundary-pushing technology development, new scientific theories, and international collaborations with our allies. They are demonstrations of our national ambition, vision, and aspirations—physical manifestations of our highest values.

Space science projects are unique to NASA in the U.S. While commercial and private companies provide invaluable expertise and mission support, there are no alternative funding sources to pursue exploration science in space. These capabilities, once lost, cannot be quickly reconstituted nor replaced by private sector activities.

China's Comprehensive Space Science Strategy

China understands the value of space science for its long-term space strategy. Their program and capabilities have grown rapidly over the past few decades, going from a handful of missions in the 2000s to at least 25 planned for the Moon and beyond in the 2020s. There are likely to be 30 or more missions planned for the coming decades across every scientific discipline in the space sciences.

The contrast to the FY 2026 budget request is stark: where the U.S. proposes cancellation, China has plans to explore. Where the U.S. limits its vision, China has ambitions to expand. This holds true for projects across all major divisions of space science, including Earth monitoring, solar physics, outer planets exploration, and deep space cosmology.

China advances its space science efforts as America considers retreat
As China moves forward with an ambitious slate of missions, the U.S. weighs deep cuts to NASA's science portfolio.

	CHINA	UNITED STATES
Earth's Magnetic Field	✓ Solar wind Magnetosphere Ionosphere Link Launching in 2026.	✗ Magnetospheric Multiscale Mission Operational. Terminated in FY26 PBR.
Universe / Exoplanets	✓ Xuntian Space Telescope Launching in 2026.	✓ Nancy Grace Roman Space Telescope Cut by 58% in FY26 PBR. Launching in 2027.
Asteroid Apophis	✓ Apophis Recon Swarm Proposed for 2027 launch.	✗ OSIRIS-Apophis Explorer Operational. Terminated in FY26 PBR.
Exoplanets	✓ Earth 2.0 Space Telescope Launching in 2028.	✗ Habitable Worlds Observatory Under study for 2030s. 90% cut in FY26 PBR.
Mars Sample Return	✓ Tianwen-3 Launching in 2028.	✗ Mars Sample Return In development. Canceled in FY26 PBR.
Jupiter	✓ Tianwen-4 Launching in 2029.	✗ Juno Operational. Terminated in FY26 PBR.
Gravitational Waves	✓ Taiji-2 Launching in 2030.	✗ Laser Interferometer Space Antenna ESA partnership. 2030s. Canceled in FY26 PBR.
Venus	✓ Venus Atmosphere Sample Return Proposed for 2033.	✗ DAVINCI and VERITAS In development. 2033. Canceled in FY26 PBR.
Ice Giant Planets	✓ Neptune-Triton Mission Under study for 2039.	✗ Uranus Flagship Mission Under study for 2030s. Canceled in FY26 PBR.

CREDIT: MAXWELL ZHU AND CASEY DREIER THE PLANETARY SOCIETY

Congressional Leadership and the Path Forward

We commend this Committee's leadership in developing the draft NASA Authorization Act earlier this year, which recognizes the importance of maintaining a balanced NASA portfolio including robust science programs. The bill's support for Mars Sample Return, the Nancy Grace Roman Space Telescope, and the Geospace Dynamics Constellation, among other priorities, demonstrates an understanding that American space leadership requires commitments to breakthrough scientific exploration. We have seen similar support from both House and Senate appropriators who, in their FY 2026 Commerce, Justice, Science appropriations bill, fully or mostly reject the proposed cuts to NASA science funding in FY 2026.

We urge the Committee to strengthen the Authorization Act by:

1. *Forbidding the OMB from prematurely cancelling science missions and other congressional priorities.* NASA should prioritize continuation of scientifically productive projects that have received recommendations for continuation by independent review committees.
2. *Explicitly re-authorizing flagship missions* under threat, including Mars Sample Return and the Habitable Worlds Observatory, areas where China is making parallel investments and progress.
3. *Reinforcing the decadal survey* with mandatory mid-decadal reviews and protections against arbitrary cuts that would undermine community-consensus priorities.
4. *Further codifying planetary defense* as a critical responsibility and providing directives to maintain the OSIRIS-APEX mission to study the close approach of the asteroid Apophis in 2029.
5. *Establishing funding consistency provisions* to prevent the OMB from preemptively imposing cuts that ignore clear congressional intent.
6. *Maintaining Research & Analysis funding* at no less than 10 percent of each science division's budget, preserving the intellectual infrastructure that enables American competitiveness in space exploration.

Conclusion

If Congress believes the U.S. faces a critical space race, then the competition extends far beyond the Moon. It encompasses Mars sample return, planetary defense, solar system exploration, the origins of the cosmos, and the search for life beyond Earth. China's systematic investments across these domains suggest these are broad priorities that stand to provide historic scientific breakthroughs to the Nation that pursues them.

The proposed NASA Authorization Act draft demonstrates the committee's recognition that space science is integral to American space leadership. The Planetary Society urges you to strengthen these provisions and ensure they become law.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. ROGER WICKER TO
ALLEN CUTLER

Government and Commercial Space Partnerships

The John C. Stennis Space Center is home to NASA's largest propulsion and engine test site. It also hosts commercial space companies. NASA increasingly relies on the commercial space sector to execute its mission. At the Center, NASA supports the commercial space industry, including by providing water and chemicals, such as nitrogen and hydrogen.

The One Big Beautiful Bill Act (OBBBA) allocated over \$9 billion for NASA, including \$120 million for infrastructure projects at the Stennis Space Center. Outside of the OBBBA, I introduced the Engine Testing for Exploration Act and the Building Out Optimized Space Testing (BOOST) for Engines Act, which would require NASA to continue rocket propulsion testing at the Stennis Space Center and continue modernization efforts for rocket propulsion test infrastructure at NASA centers.

It is important for the United States government to both grow the commercial space industry and maintain government activity in space, especially as our key competitors, China and Russia, have increased their space presence and developed launch vehicles capable of reaching all orbits and satellite constellations for remote sensing, navigation, and communications.

Question. NASA's John C. Stennis Space Center in Mississippi serves as America's largest rocket propulsion test site and exemplifies how NASA can work with commercial space industry. The historic investments in the One Big Beautiful Bill Act will bolster the Stennis Space Center's equities through critical infrastructure improvements and engagement with the commercial space sector. How can we continue to leverage government and commercial partnerships to maximize utilization of NASA centers and achieve our space missions?

Answer. We can continue to maximize the value of NASA centers such as Stennis Space Center (SSC) by strengthening government–industry partnerships that align national priorities with commercial innovation and investment. The key is to treat facilities like Stennis not only as Federal assets but as national infrastructure that enables both NASA's exploration missions and the broader growth of the U.S. space economy.

First, partnerships should expand the shared-use model that allows government programs and commercial operators to access the same testing infrastructure. At Stennis, this means leveraging the world-class propulsion test stands for both Artemis-class engines and privately developed launch systems. By diversifying the user base, NASA sustains critical capabilities, offsets fixed costs, and accelerates innovation across multiple programs.

Second, NASA can emphasize flexible contracting mechanisms, including reimbursable Space Act Agreements, Enhanced Use Lease Agreements, public-private partnerships, and firm-fixed-price contracting for mature systems. These mechanisms reduce overhead, increase efficiency, and allow commercial providers to invest in upgrades that benefit themselves and SSC.

Third, a stronger commitment to regional economic integration ensures that centers like Stennis remain vital engines of growth. Partnerships with state governments, universities, community colleges, and workforce development programs can expand the talent pipeline, while commercial tenancy drives stable demand and creates an ecosystem around the center.

Finally, NASA should deliberately use these partnerships to foster resilience and sustainability in national capability. By ensuring that multiple companies and programs rely on shared infrastructure, NASA reduces single-point vulnerabilities and creates an enduring foundation for deep space exploration.

Maximizing utilization of NASA centers requires moving beyond a purely government-led model to one where public and private actors co-invest, co-operate, and co-benefit. Doing so will help the center remain a cornerstone of America's civil space program while anchoring the next generation of commercial space growth.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. DAN SULLIVAN TO
ALLEN CUTLER

1. Kodiak's Pacific Spaceport: The Arctic Launch Advantage

"Alaska is home to the Pacific Spaceport Complex on Kodiak Island, which offers rare U.S. access to high-inclination and polar orbits. These trajectories are critical for Earth observation, national security, and Arctic monitoring—but they can't be reached from most U.S. launch sites in the lower 48. Given that China is expanding its launch capability and building Arctic partnerships, how is NASA leveraging

Kodiak’s spaceport to ensure secure U.S. launch access into polar orbit? And what investments or partnerships should Congress prioritize to grow this strategic infrastructure?”

Answer. As more entrants come into the launch market, more pressure will be placed on infrastructure to accommodate the growing needs of the launch community related to polar orbits and other science, exploration, commercial, and national security missions. Congress could direct NASA to forecast its future use of Federal launch facilities based on planned missions, helping determine whether projected launch activity will exceed current infrastructure capacity.

2. ASF: NASA’s Only SAR Data Center Is in Alaska

“NASA’s Alaska Satellite Facility (ASF) at the University of Alaska Fairbanks is the agency’s only center for receiving and processing synthetic aperture radar (SAR) satellite data. This data supports disaster response, Arctic monitoring, agriculture, and military logistics, and is critical in cloudy or dark environments—like the Arctic. China and Russia are rapidly advancing SAR satellite capabilities. If NASA moves forward with proposed cuts to ASF, what would be the national and global implications for data continuity, disaster readiness, and Arctic situational awareness?”

Answer. Reducing funding for the ASF could create gaps in SAR data continuity, slow and degrade disaster response, and weaken Arctic situational awareness. These potential outcomes raise national security, economic, and human risks domestically and internationally.

3. Arctic Blind Spots in Navigation and Communications

“Much of the Arctic still lacks reliable satellite-based communications, navigation, and surveillance—gaps that become more urgent as sea lanes open and adversaries increase activity in the region. Alaska’s infrastructure could help bridge that gap. What steps is NASA taking—or should it take—in partnership with other agencies, to develop or deploy technologies that support persistent Arctic space-based coverage for communication and navigation? How can we ensure the Arctic doesn’t remain a strategic blind spot?”

Answer. While CDSE believes reliable satellite-based communications, navigation, and surveillance are important, CDSE does not have any insight into NASA’s plans to support Arctic space-based coverage.

4. Poker Flat: The U.S.’ Only High-Latitude Rocket Range at Risk

“The Poker Flat Research Range near Fairbanks is the only U.S. sounding rocket range in the high latitudes. It provides low-cost, rapid launch capability for atmospheric and aurora research and supports student training and workforce development. But without renewed NASA investment, it may shut down by 2028. Given the national security implications of Arctic space weather and the affordability of this launch site, what is the rationale for allowing it to atrophy? How does NASA plan to preserve U.S. launch presence in the polar region?”

Answer. The Artemis program and the race with China to the Moon utilize launch resources at Kennedy Space Center for launch. While CDSE understands that the Poker Flat Research Range provides unique research capabilities, CDSE does not have any insight into NASA’s plans regarding this facility.

5. Space Weather: Arctic Aviation and Infrastructure Depend on It

“The Geophysical Institute at UAF leads some of the most advanced research in space weather and geomagnetic storms, which pose serious risks to aviation safety, power grids, and communications—especially in the Arctic, where magnetic interference is strongest. With NASA proposing cuts to these programs, what’s the potential operational impact on commercial and defense aviation routes over the Arctic? Can the U.S. afford to scale back space weather forecasting in this region when these disruptions are only expected to grow?”

Answer. Space weather affecting commercial and Defense aviation does not fall within the purview of CDSE and its activities, which relate to human exploration of the Moon and eventually Mars. However, understanding space weather is critical to human exploration in terms of radiation shielding for spacecraft, space stations, and structures on the lunar surface. Heliophysics research also plays a role in understanding the space environment for communications and other activities around the Moon.

6. Protecting the STEM Pipeline and National Talent Base

“Alaska institutions like the Geophysical Institute don’t just conduct critical research—they also train the next generation of space physicists, engineers, and atmospheric scientists. But NASA’s program mergers and delayed awards are already

causing labs to lose students and postdocs. How concerned should we be about the long-term loss of this talent pipeline—not just in Alaska but nationally—if funding uncertainty continues to drive students and faculty out of space science fields?”

Answer. There are far-reaching consequences to funding uncertainty in the sciences. The country has profited from the inspiration generated by NASA since its inception. The technical aerospace workforce for generations has come from watching our triumphs in space. That inspiration has benefited all scientific disciplines as students find initial interest in seeing NASA missions, but then stay in STEM fields as careers, even if they never work on a space mission. When those students see fewer grants and job opportunities because of funding uncertainty, the pipeline of technically trained students that become the country’s future workforce becomes broken.

Students seek other careers and turn their interests to other educational pursuits. This leads to shortages in the aerospace workforce for critical technical jobs and a diminished capacity for the country to innovate and lead for years. Our aerospace industry relies on this pipeline so that companies are prepared to step in when NASA needs the ability to explore.

7. China’s Arctic and Polar Ambitions vs. U.S. Inaction

“China is investing in new polar research bases, satellites optimized for Arctic observation, and even new Arctic shipping routes to advance its space and geopolitical aims. Meanwhile, core Arctic science and space infrastructure in the U.S.—like ASF and Poker Flat—is facing funding cuts or operational risk. What should Congress do right now to make sure the United States doesn’t lose its strategic space foothold in the Arctic, particularly when China is aiming to fill any gaps we leave behind?”

Answer. China’s activities in the Arctic are similar to those it uses to advance its ambitions in space exploration. For Artemis, reducing funding at a time when our adversaries are steadily making investments and advancements in strategic capabilities for lunar exploration is counterproductive. The country stands to lose its position as the world’s leader in science and space exploration if funding for these activities is reduced.

8. Transparency and Stability in NASA Grantmaking

“Alaska researchers are facing major uncertainty under the new ROSES 2025 program restructures, with some merged solicitations seeing up to 75 percent funding reductions and others marked ‘TBD.’ These cuts directly impact Arctic science. Should Congress require NASA to provide more transparency and predictability in how these funding lines are combined and awarded? And what safeguards should be considered to protect regionally essential research capacity from being lost in broad program reshuffles?”

Answer. CDSE represents members of the aerospace industry, but their concerns are not different from academia. Program stability is key to being able to optimize plans and ensure that a solid foundation is being laid to address any future challenges. Congress should pass a robust NASA authorization bill that covers several years to continue successful policies and strengthen our investments across academia and industry. Continuity is key to growing our country’s aerospace industry capabilities and sustaining global leadership in space. Similarly, maintaining a stable and consistent funding stream for academic research will allow for predictable opportunities for making grant proposals. CDSE encourages Congress to identify and fund research priorities in authorizing and annual spending bills.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
ALLEN CUTLER

The Moon Race with China—How do we win

Each of the witnesses during testimony and questioning at the hearing said that winning the race against China to the Moon, not only to land again, but to establish a permanent presence, is vitally important, and each witness expressed varying levels of concern that the U.S. is likely to lose without changes to the current approach.

Question 1. Mr. Cutler, if we are serious about beating China to the moon and being a first mover when it comes to establishing a sustainable presence in important areas of the lunar surface, what three things do we absolutely need to do as a nation right now?

Answer. First and foremost, Congress must maintain the constancy of purpose that has been at the foundation of the Artemis program. The base elements of the Space Launch System (SLS), the Orion capsule, and the necessary Exploration

Ground Systems support to launch crews to the Moon have been central to the program from the start. Since its inception, Congress has served as a stabilizing force through successive authorization bills, each vital to the Artemis program's continuity, as various administrations sought to reshape it with their own priorities. Amid these shifts, it was congressional unity and resolve that proved essential in bringing Artemis to where it stands today. A multi-year authorization bill continuing the path that has been supported by Congress and multiple Administrations is key.

That steady presence creates an environment where additional national benefits can be realized. Removing whipsaw policy changes and an irregular launch cadence in the program allows industry, from the prime contractors, down to the small businesses that supply critical parts, to work in a predictable environment. Predictability helps to align supply chain management to optimize the workforce and production costs for each upcoming Artemis mission.

The consistency that Congress can provide to Artemis also benefits our Nation's future workforce, as students see STEM workforce opportunities from a successful exploration program. K-12 and post-secondary students become excited about being a part of space as they see a national commitment to Artemis. Uncertainty can lead students to pursue alternative education paths that could have negative impacts on the aerospace industry for years into the future.

For Artemis to be successful in establishing a presence on the Moon before China, Congress cannot disrupt the consistent support it has shown for many years.

Secondly, in a multi-year authorization, Congress has the opportunity to create a procurement environment at NASA that will enable efficiency and competition across human exploration. Currently, NASA utilizes contracts for Artemis that require significant levels of agency oversight for SLS and Orion. These contracts were done at a time when NASA was not comfortable with a NASA insight model versus a NASA oversight model. The result creates significant costs that were intended for developing vehicles, and not for vehicles in production. NASA's application of its procedures is uneven across Artemis and contributes to higher costs and slower production schedules.

If Congress offered an avenue for the removal of burdensome requirements and procedures, without compromising safety, costs could be reduced, and additional options for competition in the Artemis program could be provided.

Finally, the country has spent decades building the infrastructure needed to accomplish NASA's missions. This infrastructure extends beyond NASA's facilities. It includes the vibrant and innovative industrial base that exists because NASA depends on its unique capabilities to achieve mission success.

Congress should ensure that the Administration does not pursue policies that inadvertently damage the capabilities this Nation has developed and make it impossible to compete on a global stage. Once capabilities are lost, it can take years to recover them. As an example, after the space shuttle was retired in 2011, the U.S. was not able to fly its astronauts from U.S. soil until 2020. If we are to remain leaders in exploration and keep ahead of our adversaries, like China, we need the full capabilities of our aerospace supplier base to be at the country's disposal.

Importance of NASA Science, Space Technology, and Aeronautics Funding

NASA's exploration programs depend on steady investment in science and in space technology development, often carried out in partnership with industry.

The President's FY26 budget proposes to cut NASA's Science Mission Directorate by about 47 percent and to reduce the Space Technology Mission Directorate by over 48 percent.

In contrast, the Senate Commerce-Justice-Science proposal restores this funding, protecting the science and technology investments that underpin the Moon-to-Mars strategy and U.S. space leadership.

Question 1. Without robust funding for NASA's science and space technology programs are we ceding our country's long-term space leadership to China and other competitors?

Answer. NASA's budget represents a small portion of the total discretionary budget at less than half of a percent, yet strong funding and policies for NASA create significant results that benefit the country. Overcoming the engineering and technical challenges that are a part of NASA's science missions and investments in space technology development propels our Nation's technical capabilities forward. The technologies and missions necessary for pushing the envelope to accomplish missions in space create technical jobs and expertise, economic growth in our local communities, and inspire future generations to pursue STEM-related fields of study. Each aspect generates advantages that lead to maintaining U.S. long-term leadership in space. NASA's funding must account for the full spectrum of its activities,

as each element contributes to the success of its missions through mutual support and integration. China is not waiting to see what the U.S. does; it is moving forward in all aspects of space exploration.

Question 2. Do you support strong NASA-industry partnerships in the aeronautics sector to advance pre-competitive technologies, such as advanced materials manufacturing? How important are these collaborations for U.S. aerospace competitiveness?

Answer. The work that NASA does across its portfolio benefits the agency, no matter where the investment occurs. Materials research done for hypersonic development or other aerospace activities brings new capabilities and solutions that can be applied to other NASA missions and spin-offs to industry. The investments in technologies that NASA has made over decades, and continues to do so, have created a vibrant aerospace industry that innovates and is prepared to take on the challenges of current and future missions. Partnerships with industry advancing our Nation's space goals continue to benefit the country, and NASA should ensure that early technology intellectual property directly funded by taxpayers remains a public good.

Mars Readiness Projections

There is a lot of excitement about sending humans to Mars. But a safe mission will depend on systems we are still developing, including life support for long missions, reliable propulsion for deep space travel, and the equipment needed to live and work on the surface. The Moon gives us a place to test these technologies and prepare.

Before changing the current plan, Congress needs a clear sense of when a safe human mission to Mars will actually be possible.

Question 1. Based on your experience and understanding of current programs, when do you believe a safe and successful human mission to Mars will be feasible?

Answer. Eventually, we will be able to have a human mission to Mars. It will only be possible through the lessons we learn from sustained missions to the Moon. Power infrastructure, supply logistics, communications, surface structures, and systems development are all necessary for a human mission to Mars, but must first be proven and refined as part of NASA's lunar exploration program. The knowledge gained about every aspect of living on another celestial body will directly impact the ability to have a safe human mission to and return from Mars. Because the missions for a sustained presence on the Moon remain in their early stages, it is difficult to predict when a human mission to Mars is feasible. What is important to the timeline is that the building blocks are being put into place. The Space Launch System, Orion, the necessary Exploration Ground Systems, the Gateway orbiting outpost, spacesuits, and landers are in development and will form the basis of extending our reach to the Moon. As NASA learns from the next step of exploration, it will be able to develop capabilities that will eventually lead to a human mission to Mars.

Designating NASA as a National Security Agency

An August 28 Executive Order titled "Further Exclusions from the Federal Labor-Management Relations Program" reclassified NASA and other agencies as having intelligence or national security as a *primary* function, thereby excluding their employees from collective bargaining rights. This marks a significant departure from NASA's foundational identity, defined by the *National Aeronautics and Space Act of 1958* (P.L. 85-568), as a civilian agency exercising control over aeronautical and space activities sponsored by the United States, distinct from department of Defense activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States). [51 U.S. Code § 20102—Congressional declaration of policy and purpose].

Question 1. Are you concerned that there may be unintended consequences of promoting this national security designation for NASA? For example, having a negative impact on the agency's ongoing efforts to pursue the utilization of aeronautical and space activities for peaceful and scientific purposes and pursue cooperation with other nations and groups of nations in the peaceful exploration and use of outer space for civil and commercial purposes?

Answer. NASA, from its inception, is a civilian space agency. The law creating NASA, the National Aeronautics and Space Act of 1958 (Public Law 85-568), explicitly states:

“The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States”

A change in NASA’s primary focus to national security could directly impact the perceived actions and motivations of the agency. Numerous government agencies that conduct activities in space in the national security domain, and our country has been successful in navigating the separation between defense and non-defense space activities to our advantage. Historically, this specific delineation of activities in space allows partnerships between NASA, industry, and other nations that would not otherwise be possible.

NASA Centers Funding in Reconciliation

I want to acknowledge Chair Cruz for his work on ensuring strong funding for NASA human space exploration through the reconciliation process. However, there are aspects of the guidance to NASA in the reconciliation law that I do not support, including the disparity in construction and infrastructure funding contained in the law, with \$1 billion provided to only five centers.

Question 1. Do you believe it is essential that all 10 field centers, their supporting facilities, and the Jet Propulsion Laboratory receive sufficient infrastructure and construction funding to maintain NASA as the world’s preeminent aerospace agency?

Answer. All of NASA has significant infrastructure challenges. In 2024, the National Academies of Sciences, Engineering, and Medicine included in their report “NASA at a Crossroads: Maintaining Workforce, Infrastructure, and Technology Preeminence in the Coming Decades” a chapter on NASA infrastructure. In that report, it was indicated that NASA had over \$3.3 billion in deferred maintenance and construction activities across all of NASA’s centers and associated physical and systems infrastructure. The funds provided in the budget reconciliation bill will create some relief to the overall infrastructure and construction backlog at NASA and may allow for resources provided in the annual appropriations process to prioritize remaining NASA maintenance and construction activities across all of NASA’s field centers.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO
ALLEN CUTLER

STEM Engagement

I have long supported programs that train students in STEM. In 2017, my bill authorizing the NASA Administrator to encourage women to study STEM and pursue careers in aerospace through NASA initiatives was signed into law.

Question 1. Why is it important for America to have a robust pipeline of talent entering the aerospace field?

Answer. Maintaining a strong aerospace pipeline requires both demand for a workforce and the development of one. NASA’s missions inspire students to pursue STEM careers and create opportunities for industry to contribute to national goals. NASA’s 2023 Economic Impact Report highlights the scale of this return: \$75.6 billion in economic output nationwide, with Artemis and Moon to Mars alone generating nearly \$24 billion in activity and supporting almost 100,000 jobs from \$7.6 billion in funding. A three-to-one return on investment. These programs create high-skill jobs, strengthen state economies, and fuel innovation across industries.

Talent is distributed nationwide and across all demographics, but it remains underdeveloped. Women represent half the U.S. population yet make up only 24 percent of the STEM workforce, according to the National Science Foundation. Expanding participation is essential to meet workforce needs as STEM-related fields continue to expand.

A shortage of aerospace talent would risk America’s leadership in space, allow competitors like China to close the gap, and limit the benefits of aerospace innovation as potentially fewer technologies become available to be spun off to other industries. By developing and sustaining a strong pipeline through investment in STEM education and workforce development, the United States can secure its technological edge, safeguard national security, and maximize returns on public investment.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BEN RAY LUJÁN TO
ALLEN CUTLER

Question 1. The Flight Opportunities Program is a cornerstone of U.S. space competitiveness, enabling researchers to rapidly test and refine technologies in sub-orbital environments that simulate the harsh conditions of space. By advancing these capabilities before costly orbital missions, the program lowers risks, reduces costs, and accelerates the readiness of innovations critical to NASA and commercial space ventures. In doing so, it strengthens the U.S. position in the global space race, ensuring domestic companies can outpace international rivals in developing and commercializing next-generation space technologies. How can NASA broaden collaborations with innovative sub-orbital commercial companies, via programs such as the Flight Opportunities or similar initiatives, to integrate their fast-iterative testing models? To match China's swift pace, what investments or policy reforms could NASA implement to more fully embed sub-orbital providers into core programs?

Answer. Congress could encourage the flight opportunities program to be a part of the process for developing capabilities that can inform and be implemented into programs like Artemis to help maintain our lead over China. If appropriate, sub-orbital missions could allow for advancing technology readiness levels of technologies that are in development, which could be incorporated into NASA's missions or as standalone missions. NASA holds an annual gathering of industry and academia to discuss the technologies and goals for its Moon to Mars program. Working with experts across the agency, industry, academia, and the international community, the architecture's blueprint evolves for exploration as NASA learns and could include development via suborbital launches as another tool to advance humanity on its path to the Moon and Mars.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN HICKENLOOPER TO
ALLEN CUTLER

NASA Science Missions Cuts

Recently, NASA was directed to begin drafting "close-out" plans for a large number of ongoing science missions. These missions include the MAVEN mission, which is led by CU Boulder's Laboratory for Atmospheric and Space Physics (LASP). MAVEN is actively collecting essential data about the atmosphere on Mars. Scientific discoveries like those MAVEN is making will be absolutely essential for successfully landing humans on Mars.

Question 1. Mr. Cutler, how would cuts to NASA science funding undermine our ability to safely and effectively explore deep space?

Answer. Underfunding NASA science directly undermines the foundation needed for safe and effective deep space exploration. Science missions generate critical data that informs spacecraft design, life support systems, and operational planning. For example, planetary science identifies potential landing sites and hazards, and heliophysics research tracks solar radiation that threatens astronaut health. Both are integral to the success of human missions to the Moon and eventually Mars. Reducing funding for these programs forces human exploration missions to proceed with less information, increasing risk, cost, and uncertainty for astronauts and hardware operating far from Earth.

Question 2. Mr. Cutler, what are the short- and long-term risks of under-investing in this fundamental work?

Answer. The short-term risks of under-investing in fundamental research include gaps in mission-critical data that directly affect crew safety and mission design. Reduced funding also narrows opportunities for industry and academic partners, weakening the innovation pipeline that supports near-term exploration goals.

Long-term risks are even more consequential. Under-investment erodes U.S. technological leadership, allowing competitors like China to set the pace in lunar and Mars exploration. It also undermines the broader STEM pipeline by reducing opportunities for students and early-career scientists to engage in discovery-driven projects, creating workforce shortages in future decades. Over time, the Nation risks higher mission costs, diminished international leadership, and weakened returns on public investment in space.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN FETTERMAN TO
ALLEN CUTLER

The NASA Space Grant funds pre-college and public service education projects in all 50 states, DC, and Puerto Rico, and fills a vital role in preparing the next generation of the space workforce. In Pennsylvania, the Space Grant is operated by Penn State, which leads a consortium of 16 colleges and universities around the commonwealth in space education and research programming in support of the needs of the NASA Mission Directorate.

We know that Chinese universities are training a highly skilled workforce and have built one of the world's most advanced remote sensing space programs. There is bipartisan acknowledgement of the race we are in with respect to space exploration.

Question 1. What actions should U.S. universities take to ensure we remain globally competitive, and how can Space Grant institutions best align with NASA's workforce and research priorities to sustain American leadership in space science and technology?

Answer. Universities should look to expand their role as engines of talent and innovation to ensure America remains globally competitive in space science and technology through strengthening STEM education pipelines at every level, from undergraduate through doctoral training. Universities have the capability to broaden participation of rural and underserved communities that remain an untapped source of talent. They can also deepen partnerships with industry to provide students with hands-on experience that matches current workforce demands. Space Grant institutions are uniquely positioned to align with NASA's goals and can act as state and regional hubs for workforce development, expanding opportunities for students to enter aerospace fields.

Question 2. What steps should Congress take to ensure that NASA's reauthorization provides the long-term stability and investment universities need to contribute fully to U.S. leadership in space, especially as adversaries seek to set their own rules of the road?

Answer. CDSE represents members of the aerospace industry, but their concerns are not different from academia. Stability is key to being able to optimize plans and ensure that a solid foundation is being laid to address any future challenges. Congress should pass a robust NASA authorization bill that covers several years to continue successful policies and strengthen our investments. Continuity is key to growing our country's capabilities and sustaining global leadership in space. Industry needs a skilled workforce across all levels of education to be successful, and programs like Space Grant provide states the ability to identify students and programs that help grow our workforce to ensure we have the workforce needed in the future.

Question 3. What are the risks to our existing workforce pipeline if funding for NASA Space Grants or similar K-12 STEM program is interrupted, withheld, or reduced?

Answer. Actions that negatively affect program stability for NASA Space Grant or similar K-12 STEM programs could pose a risk to the Nation's workforce pipeline. It narrows access to discovery-driven educational opportunities that inspire students to pursue careers in STEM.

Without consistent exposure and hands-on engagement, fewer students will advance into higher education and technical fields, creating gaps in the aerospace workforce that may take decades to repair.

This disruption also undermines the broader STEM pipeline by reducing opportunities for students and early-career scientists to gain critical skills and experiences needed to transition into aerospace and related industries. Over time, workforce shortages will weaken the Nation's capacity to execute ambitious exploration missions and to compete globally.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER WICKER TO
MICHAEL GOLD

Government and Commercial Space Partnerships

The John C. Stennis Space Center is home to NASA's largest propulsion and engine test site. It also hosts commercial space companies. NASA increasingly relies on the commercial space sector to execute its mission. At the Center, NASA supports the commercial space industry, including by providing water and chemicals, such as nitrogen and hydrogen.

The One Big Beautiful Bill Act (OBBBA) allocated over \$9 billion for NASA, including \$120 million for infrastructure projects at the Stennis Space Center. Outside

of the OBBBA, I introduced the Engine Testing for Exploration Act and the Building Out Optimized Space Testing (BOOST) for Engines Act, which would require NASA to continue rocket propulsion testing at the Stennis Space Center and continue modernization efforts for rocket propulsion test infrastructure at NASA centers.

It is important for the United States government to both grow the commercial space industry and maintain government activity in space, especially as our key competitors, China and Russia, have increased their space presence and developed launch vehicles capable of reaching all orbits and satellite constellations for remote sensing, navigation, and communications.

Question. NASA's John C. Stennis Space Center in Mississippi serves as America's largest rocket propulsion test site and exemplifies how NASA can work with commercial space industry. The historic investments in the One Big Beautiful Bill Act will bolster the Stennis Space Center's equities through critical infrastructure improvements and engagement with the commercial space sector. How can we continue to leverage government and commercial partnerships to maximize utilization of NASA centers and achieve our space missions?

Answer. The key to maximize the utility of Stennis and the facilities at all human spaceflight centers is for NASA to maintain continuity. Specifically, per my testimony, NASA must sustain the Artemis program and remain focused on returning to the Moon, before China, and ensuring robust, ongoing, and permanent operations in orbit and on the surface of the Moon. We must proceed with Artemis II and III with as much alacrity as possible, and pivot to commercial systems as soon as they are available (with the caveat that America should never be dependent on a single launch system/vehicle for its lunar exploration activities).

Moreover, NASA must leverage not only commercial but international partnerships as well. International partnerships are and will continue to be critical to both Artemis and space-based entrepreneurship. Numerous nations are already contributing to Artemis via the Gateway and the International Space Station. Most of these partnerships represent relatively traditional barter style partnerships. However, several countries are looking to engage with the American private sector in more innovative ways. For example, Saudi Arabia, a prominent Artemis Accords signatory, represents a partner with incredible potential to transform commercial space. Specifically, Redwire was honored to host a visit in April from the Saudi Space Agency (SSA) led by His Excellency Dr. Mohammed Altamimi the CEO of the SSA. Redwire and the SSA are exploring how the two organizations can work together, with a potential focus on Redwire's trailblazing pharmaceutical and microgravity capabilities. Such international partnerships have the potential to transform the space field, since organizations like the SSA are concentrating on innovative space commercialization in a manner that could dramatically accelerate global progress.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. DAN SULLIVAN TO
MICHAEL GOLD

1. Kodiak's Pacific Spaceport: The Arctic Launch Advantage

"Alaska is home to the Pacific Spaceport Complex on Kodiak Island, which offers rare U.S. access to high-inclination and polar orbits. These trajectories are critical for Earth observation, national security, and Arctic monitoring—but they can't be reached from most U.S. launch sites in the lower 48. Given that China is expanding its launch capability and building Arctic partnerships, how is NASA leveraging Kodiak's spaceport to ensure secure U.S. launch access into polar orbit? And what investments or partnerships should Congress prioritize to grow this strategic infrastructure?"

Answer. NASA should pro-actively work with existing and future commercial launch partners to ensure that they can and are utilizing the Kodiak spaceport.

2. ASF: NASA's Only SAR Data Center Is in Alaska

"NASA's Alaska Satellite Facility (ASF) at the University of Alaska Fairbanks is the agency's only center for receiving and processing synthetic aperture radar (SAR) satellite data. This data supports disaster response, Arctic monitoring, agriculture, and military logistics, and is critical in cloudy or dark environments—like the Arctic. China and Russia are rapidly advancing SAR satellite capabilities. If NASA moves forward with proposed cuts to ASF, what would be the national and global implications for data continuity, disaster readiness, and Arctic situational awareness?"

Answer. Potential cuts should be reversed and we should be putting more resources into SAR data collection and analysis. Anything less will cede critical military and economic benefits to China and Russia.

3. Arctic Blind Spots in Navigation and Communications

“Much of the Arctic still lacks reliable satellite-based communications, navigation, and surveillance—gaps that become more urgent as sea lanes open and adversaries increase activity in the region. Alaska’s infrastructure could help bridge that gap. What steps is NASA taking—or should it take—in partnership with other agencies, to develop or deploy technologies that support persistent Arctic space-based coverage for communication and navigation? How can we ensure the Arctic doesn’t remain a strategic blind spot?”

Answer. NASA and other Federal agencies and departments should partner with private sector satellite companies to fill these blind spots with innovative, new, and affordable systems. Additionally, the launches should take place from Kodiak.

4. Poker Flat: The U.S.’ Only High-Latitude Rocket Range at Risk

“The Poker Flat Research Range near Fairbanks is the only U.S. sounding rocket range in the high latitudes. It provides low-cost, rapid launch capability for atmospheric and aurora research and supports student training and workforce development. But without renewed NASA investment, it may shut down by 2028. Given the national security implications of Arctic space weather and the affordability of this launch site, what is the rationale for allowing it to atrophy? How does NASA plan to preserve U.S. launch presence in the polar region?”

Answer. I can’t speak for NASA, but I personally believe we should increase investment in Poker Flat and ensure that it is protected from adversary drone strikes.

5. Space Weather: Arctic Aviation and Infrastructure Depend on It

“The Geophysical Institute at UAF leads some of the most advanced research in space weather and geomagnetic storms, which pose serious risks to aviation safety, power grids, and communications—especially in the Arctic, where magnetic interference is strongest. With NASA proposing cuts to these programs, what’s the potential operational impact on commercial and defense aviation routes over the Arctic? Can the U.S. afford to scale back space weather forecasting in this region when these disruptions are only expected to grow?”

Answer. Due to the growing importance of the Arctic as temperature rises increase access to additional land and resources, we should increase space weather funding rather than cutting it. The U.S. is more dependent on space-based capabilities for both military and economic health than at any time in our nation’s history. Therefore, failing to properly fund space weather infrastructure could have disastrous consequences.

6. Protecting the STEM Pipeline and National Talent Base

“Alaska institutions like the Geophysical Institute don’t just conduct critical research—they also train the next generation of space physicists, engineers, and atmospheric scientists. But NASA’s program mergers and delayed awards are already causing labs to lose students and postdocs. How concerned should we be about the long-term loss of this talent pipeline—not just in Alaska but nationally—if funding uncertainty continues to drive students and faculty out of spacescience fields?”

Answer. Maintaining a strong pipeline of aerospace professionals will be vital if the U.S. is to successfully compete and win a competition with China. The U.S. is already far behind China in the sheer number of students and aerospace-related STEM professionals. This situation will only grow more acute over time if funding uncertainty drives students out of the space field. A lack of a capable workforce is a critical security threat to the United States. We must leverage innovative programs such as NASA’s High Schools United to Create Hardware, space grants, and other initiatives to make sure our STEM pipeline remains strong for NASA, Space Force, and the private sector. Moreover, beating China in space will require ALL of America to participate, this includes rural communities and reservations in Alaska and many other states, which can often be ignored.

7. China’s Arctic and Polar Ambitions vs. U.S. Inaction

“China is investing in new polar research bases, satellites optimized for Arctic observation, and even new Arctic shipping routes to advance its space and geopolitical aims. Meanwhile, core Arctic science and space infrastructure in the U.S.—like ASF and Poker Flat—is facing funding cuts or operational risk. What should Congress do right now to make sure the United States doesn’t lose its strategic space foothold in the Arctic, particularly when China is aiming to fill any gaps we leave behind?”

Answer. Congress and NASA should restore any cuts and explore additional funding for infrastructure improvement and expansion of America's critical Arctic facilities beginning with ASF and Poker Flat. We must not cede space, or the Arctic, to China, Russia, and/or other geopolitical adversary nations.

8. Transparency and Stability in NASA Grantmaking

"Alaska researchers are facing major uncertainty under the new ROSES 2025 program restructures, with some merged solicitations seeing up to 75 percent funding reductions and others marked 'TBD.' These cuts directly impact Arctic science. Should Congress require NASA to provide more transparency and predictability in how these funding lines are combined and awarded? And what safeguards should be considered to protect regionally essential research capacity from being lost in broad program reshuffles?"

Answer. Hard deadlines for reviews and responses, simplified application processes, and a focus on the competition with China, should all be implemented to reform and improve the NASA grantmaking process.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. TODD YOUNG TO
MICHAEL GOLD

Question 1. Will you please detail how American companies are developing revolutionary capabilities that are helping us stay first in space?

Answer. I'm of course biased, but I believe that some of the most revolutionary work in the space industry is occurring in Greenville, Indiana, where, per my testimony, Redwire is on the cutting edge of microgravity manufacturing, conducting trailblazing research and development of seed crystals that could lead to next-generation pharmaceuticals with enhanced efficacy, longevity, and/or fewer side effects. Moreover, the work occurring in Southern Indiana is building upon the foundation for the eventual fabrication of whole organs in space, which would save countless lives and dramatically improve the quality of life on Earth. However, for this incredible work to continue, Congress must ensure that NASA maintains at least four astronauts on the International Space Station and that the Agency prioritizes and has the funding for supporting advanced microgravity biotech and pharmaceutical research.

Blue Origin, which Redwire is proud to work with on solar arrays, power distribution, and cameras, is revolutionizing the space launch industry and, per my testimony, is contributing literally billions of dollars to ensure America returns to the Moon before China via its Human Landing System development contract with NASA. Additionally, Blue Origin is unilaterally funding the Mark-1 lunar lander which will launch later this year. A single private sector company making such massive financial contributions to achieving America's goal of returning astronauts to the Moon, this time to stay, is unprecedented, and should be praised and embraced by Congress and NASA.

SpaceX has of course done an extraordinary amount to keep America first in space, through the development of its rockets such as the Falcon 9 and Falcon Heavy. Moreover, SpaceX's Dragon capsule broke the deplorable American dependence on Russia for crew transportation to the International Space Station.

In addition to launching crew and cargo, the private sector is now on the verge of building and deploying commercial space stations in low-Earth orbit. For example, Redwire recently announced a contract with Axiom Space to provide solar arrays for its first module.

I could go on, the revolutionary contributions of American space companies are numerous and varied, which is important since a dynamic private space sector is vital to not just the American economy, but to our freedom. It's inevitable that China will eventually outspend America in space, therefore, it's imperative that the U.S. out-entrepreneur the Chinese. If the U.S. government continues to embrace private-public partnerships and maintains the continuity of major initiatives such as Artemis, I remain confident the revolution in space will be an American revolution.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
MICHAEL GOLD

The Moon Race with China—How do we win

Each of the witnesses during testimony and questioning at the hearing said that winning the race against China to the Moon, not only to land again, but to establish a permanent presence, is vitally important, and each witness expressed varying lev-

els of concern that the U.S. is likely to lose without changes to the current approach.

Question 1. Mr. Gold, if we are serious about beating China to the moon and being a first mover when it comes to establishing a sustainable presence in important areas of the lunar surface, what three things do we absolutely need to do as a nation right now?

Answer. 1. Secretary Sean Duffy should be nominated and quickly confirmed as the permanent NASA Administrator. We cannot beat China without strong and focused leadership. Secretary Duffy has already demonstrated an unwavering focus on beating China to the Moon, won the trust of the NASA workforce by elevating a talented space architect to the role of Associate Administrator, and has begun cultivating a constructive relationship with Congress while still providing NASA with a leader that maintains a close relationship with the President, which is invaluable to the agency. Time is of the essence, and we do not have the luxury of the months, if not longer, that identifying a new nominee, going through the vetting and confirmation process, and subsequently undergoing yet another review of NASA activities and shifting priorities that a different Administrator could bring. Additionally, there are many synergies and benefits to the Secretary of Transportation also leading NASA, such as coordinated space traffic management and leveraging a broader array of tools for international relationships. Secretary Duffy is the right leader at the right time, and his position should be made permanent with alacrity.

2. We must publicly reaffirm America's commitment to the Gateway. NASA should immediately communicate this to our international partners and domestic contractors. This will prevent China from peeling off our global support for Artemis, while ensuring that the cornerstone of a sustainable and robust American presence in cislunar space and on the surface of the Moon, the Gateway, is deployed as soon as possible. However, this is not to say that changes shouldn't be made. A rapid review of Gateway should be conducted to determine how the system and/or its orbit could be optimized to support lunar surface as well as commercial operations (e.g., the refueling of commercial landers). Additionally, NASA may want to consider the potential benefits of shifting the launch of Gateway international elements to commercial heavy lift vehicles.

3. We must also reaffirm that NASA will maintain a continuous crewed presence in low Earth orbit (LEO) and will avoid a space station gap. Moreover, the American space station(s) that succeed the International Space Station (ISS) must be more capable than any existing or future Chinese LEO platform. It's important to acknowledge the connectivity between Artemis and crewed LEO operations. Specifically, the experience, technologies, commercialization activities, and global partnerships formed in LEO serve as the foundation for Artemis's lunar and Martian capabilities.

Importance of NASA Science, Space Technology, and Aeronautics Funding

NASA's exploration programs depend on steady investment in science and in space technology development, often carried out in partnership with industry.

The President's FY26 budget proposes to cut NASA's Science Mission Directorate by about 47 percent and to reduce the Space Technology Mission Directorate by over 48 percent.

In contrast, the Senate Commerce-Justice-Science proposal restores this funding, protecting the science and technology investments that underpin the Moon-to-Mars strategy and U.S. space leadership.

Question 1. Without robust funding for NASA's science and space technology programs are we ceding our country's long-term space leadership to China and other competitors?

Answer. Absolutely. In stark contrast to making cuts, we should be increasing the funding for NASA's science and space technology programs, and I applaud the Senate Commerce Committee for supporting NASA's science and space technology budget. However, changes should be made to optimize the efficacy of both NASA science and space technology endeavors, specifically:

- Science and space technology projects should be reviewed and prioritized based on relevance to our geopolitical competition with China;
- Fiscal discipline needs to be applied to NASA's Science Mission Directorate. Programs such as James Webb which ran roughly \$9 billion over budget (a 10x cost increase over original estimates) can no longer be tolerated due to, if nothing else, the negative impact that such massive cost overruns have on the broader science portfolio; and
- The Space Technology Mission Directorate (STMD) should be reorganized to become the dynamic nexus of NASA and the private sector that it was always intended to be. For example, in lieu of Tipping Points, STMD should create stand-

ing Broad Agency Announcements (BAAs) in order to capture the best ideas that industry has to offer in a flexible and ongoing fashion. Moreover, the BAA procurement process should reflect best practices by the Defense Advanced Research Projects Agency by utilizing an initial single page proposal process to reduce the burden on companies. Such a process will broaden the ability of small and medium-sized businesses to engage with NASA and allow them to avoid wasting time developing lengthy proposals that the government does not have an interest in.

Question 2. Are there specific areas of technology where we already lag behind China that NASA should prioritize now?

Answer. There are numerous areas of technology that must be prioritized to avoid falling behind China. Specifically, NASA should prioritize microgravity R&D and manufacturing (with an initial focus on biotech and pharmaceuticals), quantum-based communications and other quantum applications (*e.g.*, quantum sensors), the extraction and utilization of space resources, solar electric propulsion, very-low Earth orbit satellite systems, and space diplomacy in the Middle East, Africa, and South America.

Mars Readiness Projections

There is a lot of excitement about sending humans to Mars. But a safe mission will depend on systems we are still developing, including life support for long missions, reliable propulsion for deep space travel, and the equipment needed to live and work on the surface. The Moon gives us a place to test these technologies and prepare.

Before changing the current plan, Congress needs a clear sense of when a safe human mission to Mars will actually be possible.

Question 1. Based on your experience and understanding of current programs, when do you believe a safe and successful human mission to Mars will be feasible?

Answer. I believe that a safe and successful human mission to Mars could be attempted as early as the next 10–15 years. However, such an ambitious schedule presumes that we proceed with alacrity to implement the Gateway, which will serve as a Mars spacecraft analogue and provide NASA with vital experience in deep space operations generally, and using an orbiting spacecraft to support surface operations specifically. Moreover, we must maintain our international partnerships, and not cede the global Artemis coalition to China, in order to properly fund and implement a safe and successful human mission to Mars before 2040.

NASA Aeronautics Research

NASA's Aeronautics Research Mission Directorate has helped make the U.S. a global leader in aerospace by developing technologies that drive commercial aviation.

But to stay ahead, we must keep investing in innovation. Right now, we're falling behind in a critical area: advanced thermoplastic composites—materials that make aircraft lighter, stronger, and more fuel efficient.

That's why NASA launched the HiCAM project, in partnership with industry, to speed up the development of these materials and apply them to the manufacture of air vehicle components. In my home state of Washington, a consortia of companies, universities, and workforce training organizations are pursuing a Tech Hub to keep the U.S. at the forefront of advanced aerospace manufacturing.

Question 1. Do you see potential applications for thermoplastic composites in space vehicles or on-orbit space platforms that could reduce cost or improve performance?

Answer. With apologies, I'm not sufficiently familiar with the benefits of thermoplastic composites to address this question.

Designating NASA as a National Security Agency

An August 28 Executive Order titled "Further Exclusions from the Federal Labor-Management Relations Program" reclassified NASA and other agencies as having intelligence or national security as a *primary* function, thereby excluding their employees from collective bargaining rights. This marks a significant departure from NASA's foundational identity, defined by the *National Aeronautics and Space Act of 1958* (P.L. 85-568), as a civilian agency exercising control over aeronautical and space activities sponsored by the United States, distinct from department of Defense activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States). [51 U.S. Code § 20102—Congressional declaration of policy and purpose].

Question 1. Are you concerned that there may be unintended consequences of promoting this national security designation for NASA? For example, having a negative impact on the agency's ongoing efforts to pursue the utilization of aeronautical and space activities for peaceful and scientific purposes and pursue cooperation with other nations and groups of nations in the peaceful exploration and use of outer space for civil and commercial purposes?

Answer. This is a challenging question since NASA's success or failure, particularly relative to the lunar competition with China and activities in LEO, will have significant national security repercussions. Therefore, there is a nontrivial argument to be made that NASA requires the exclusion from the Federal Labor-Management Relations Program per the Executive Order.

However, while such an exclusion is likely necessary, it should remain explicitly clear that NASA's purpose is to support the peaceful exploration and utilization of space for civil and commercial purposes. Unlike China, the U.S. separates its civil and national security space enterprises. This separation should be maintained to ensure the U.S. continues to show global leadership in support of peaceful, responsible, and transparent space exploration and utilization, as opposed to the opaque, dangerous, and militaristic space program that China is currently conducting.

NASA Centers Funding in Reconciliation

I want to acknowledge Chair Cruz for his work on ensuring strong funding for NASA human space exploration through the reconciliation process. However, there are aspects of the guidance to NASA in the reconciliation law that I do not support, including the disparity in construction and infrastructure funding contained in the law, with \$1 billion provided to only five centers.

Question 1. Do you believe it is essential that all 10 field centers, their supporting facilities, and the Jet Propulsion Laboratory receive sufficient infrastructure and construction funding to maintain NASA as the world's preeminent aerospace agency?

Answer. I do not believe that maintaining ten NASA field centers, their supporting facilities, and the Jet Propulsion Laboratory are all inherently necessary to the success of NASA. Instead of making cuts to vital exploration and science programs, I believe that NASA should explore saving funds and increasing efficiencies by consolidating the number and nature of its facilities across the U.S.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO
MICHAEL GOLD

Pharmaceutical/Biomedical Breakthroughs in Space

In your testimony, you describe how we are on the precipice of truly incredible breakthroughs in microgravity that could transform the pharmaceutical and biotech industries.

Question 1. What additional legislation would be helpful from Congress to advance these breakthroughs?

Answer. Thank you for the question and there are a wide variety of ways that Congress can ensure that these breakthroughs occur, and that they occur here in America instead of China, specifically:

- Congress should continue to explicitly require NASA to maintain a continuous crewed presence in LEO.
- Congress should provide NASA with robust funding for Commercial LEO Destinations (CLDs) and require NASA to both (1) avoid a gap in American crewed activities in LEO, and (2) ensure that NASA's crewed facilities and capabilities in LEO substantively exceed China's.
- Congress should provide increased funding for microgravity pharmaceutical and biotech-related research and manufacturing activities by authorizing and appropriating \$130M or more for the agency's Biological and Physical Sciences (BPS) Division. Moreover, regardless of overall budgets, NASA and CASIS should prioritize funding, as well as up and down mass and crew time, for pharmaceutical and biotech-related R&D and prototype manufacturing activities that have strong commercial potential.
- Additionally, more flexibility should be provided by Congress to the BPS Division that would enable BPS to: contract directly with CLDs to host payloads, provide up and down mass, and crew time. Also, BPS should be granted authority to place experiments and payloads on Gateway, cislunar spacecraft, spacecraft traveling to Mars, and on the surface of Mars.

- NASA should pro-actively collaborate with the National Institutes of Health, the National Science Foundation, the Department of Veterans Affairs, the Department of Defense, and any other relevant agencies and departments to utilize and become customers for the breakthrough capabilities and products that commercial space companies achieve on the ISS.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BEN RAY LUJÁN TO
MICHAEL GOLD

Question 1. China has announced not only that they plan on landing on the moon by 2030, but they also want to establish a permanent crewed lunar station by 2035, and an \$11 Billion Earth-Moon economy by 2050. According to the NASA Inspector General last year, SLS will only be able to carry out 1 Orion mission every two years for the foreseeable future. Currently, international partners fly crew to and from the International Space Station about 5 times per year. While a lunar base crew might be smaller to start, could a lunar base be functional with fewer than two missions per year? Will this cadence allow us to build a growing U.S. human presence on the Moon and dominate lunar development and settlement? If not, what frequency would be required?

Answer. Although the Inspector General (IG) has justifiably cited cost overruns and schedule delays with the SLS and Orion, I am not aware that the IG ever stated that “the SLS will only be able to carry out 1 Orion mission every two years for the foreseeable future.” NASA is currently planning to launch one SLS per year beginning in 2028. The launch of commercial lunar spacecraft could add to this launch cadence. I believe that a single launch per year, potentially augmented by commercial transportation vehicles, will be sufficient to “build a growing U.S. human presence on the Moon and dominate lunar development and settlement.”

However, per my testimony, robust lunar development can only be achieved if Gateway is deployed. With Gateway and full commercial logistics services, crewed lunar surface activities can occur for 60–90 days, enabling astronauts to conduct significant development and settlement activities including resource extraction and utilization, as well as building and deploying infrastructure such as solar arrays, nuclear reactors, landing pads, roads, and habitats. Without Gateway, crewed surface activities will be limited to 5–7 days, severely curtailing development and settlement activities and constructively ceding the lunar surface to China.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. JOHN HICKENLOOPER TO
MICHAEL GOLD

Microgravity Research in Space

Since 1999, the International Space Station has operated as the only U.S. National Lab that operates in space. The ISS and its unique microgravity environment allows proteins to grow into larger crystals than on Earth. This research contributes to breakthroughs in drug design for muscular dystrophy and certain cancers. The United States needs a steady presence in space to continue essential microgravity research.

NASA has already invested in the development of research platforms on commercial space stations; and developed plans to safely deorbit the ISS.

Question 1. Mr. Gold, how would you describe NASA’s efforts thus far to maintain the United States’ continuous presence in LEO? Would you have any recommendations to offer for NASA to improve our transition to commercial microgravity platforms?

Answer. Thank you for the question. Unfortunately, I would describe NASA’s efforts to maintain a continuous crewed presence in LEO as slow and inconsistent. Until Secretary Duffy became NASA Interim Administrator, there were indications that NASA was moving toward no longer supporting a continuous crewed presence in LEO, ceding the field to China. Moreover, after years of discussion and analysis, NASA has yet to execute commercial contracts with private sector partners to fly government astronauts on CLDs. Per language in the One Big Beautiful Bill Act, Congress is directing NASA to proceed with alacrity and has established deadlines to begin implementing the actual procurement of CLDs. I applaud Congress’s proactive engagement on this matter and hope that this Committee and your colleagues in both chambers remain vigilant to ensure that NASA proceeds with sufficient priority and urgency to prevent ceding crewed LEO activities and all of its benefits to China. Additionally, NASA should fully implement a commercial paradigm wherein the agency provides its needs and leaves the private sector to develop its own solu-

tion to address them. Moreover, programmatic and operational requirements that the Agency levies upon CLD providers should be limited as much as possible and, after agreements are executed, must remain frozen. In the meantime, while CLDs are being developed, on the ISS, NASA should prioritize relevant available funding, up and down mass, and crew time in support of microgravity activities such as biotech and pharmaceutical work, that could make substantive contributions to the business case for CLDs.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN FETTERMAN TO
MICHAEL GOLD

The NASA Space Grant funds pre-college and public service education projects in all 50 states, DC, and Puerto Rico, and fills a vital role in preparing the next generation of the space workforce. In Pennsylvania, the Space Grant is operated by Penn State, which leads a consortium of 16 colleges and universities around the commonwealth in space education and research programming in support of the needs of the NASA Mission Directorate.

We know that Chinese universities are training a highly skilled workforce and have built one of the world's most advanced remote sensing space programs. There is bipartisan acknowledgement of the race we are in with respect to space exploration.

Question 1. What actions should U.S. universities take to ensure we remain globally competitive, and how can Space Grant institutions best align with NASA's workforce and research priorities to sustain American leadership in space science and technology?

Answer. U.S. universities need to redouble their efforts to monitor and ensure that researchers are not working for or with Chinese entities when utilizing NASA or other Federal government funds. Moreover, while not ignoring fundamental science, universities should focus on applications for space science and technologies that will support commercial space activities that create jobs, innovation, and generally improve life on Earth.

Question 2. What steps should Congress take to ensure that NASA's reauthorization provides the long-term stability and investment universities need to contribute fully to U.S. leadership in space, especially as adversaries seek to set their own rules of the road?

Answer. The best step that NASA can take is to ensure that the Artemis program is sustained. NASA's inability to sustain a beyond-LEO human spaceflight program since Apollo has been devastating for the stability of investments by the agency and all of its university partners. I applaud the yeoman's work that was done in the One Big Beautiful Bill Act to restore Artemis funding and to support ISS operations as well.

In regard to setting the rules of the road, it's an excellent point to raise since NASA and America must lead not just in technology but in policy. Therefore, NASA and the Department of State must continue to increase the number of Artemis Accords signatory nations. In order to do so and ensure that we do not start losing Accords signatories to China (which has already happened in a few instances), we must quickly, strategically, and creatively find ways for Artemis Accords signatories to contribute to and become a part of the Artemis program.

Question 3. What are the risks to our existing workforce pipeline if funding for NASA Space Grants or similar K-12 STEM program is interrupted, withheld, or reduced?

Answer. One of if not the most challenging aspect of our competition with China is workforce size, expertise, and development. China's aerospace workforce dwarfs our own and China also enjoys a cultural focus on engineering, science, and math that has atrophied in America since, and in no small part because of, the short-sighted termination of the Apollo program. Therefore, to compete with China, we must do everything possible to bolster programs such as the NASA Space Grants and similar K-12 STEM initiatives. This means that all of America must participate and we cannot leave any region or demographic behind. Currently, the Space Grant consortium is the only way NASA directly touches universities and student populations in many rural states and tribal territories. We must continue to fund Space Grants in part to ensure that rural America isn't left behind.

Moreover, we should focus such efforts on providing students with real hands-on space hardware experience. For example, the High Schools United with NASA to Create Hardware (HUNCH) program, which has been utilized by Redwire, enables students from rural states and reservations to build equipment for the ISS. Due to

HUNCH, students from rural areas who weren't even expected to graduate high school, have gone on to become aerospace engineers, making contributions to Gateway and numerous other human and robotic spaceflight systems. It's through programs like HUNCH that we can ensure that America maximizes and optimizes its aerospace workforce, enabling NASA, Space Force, and the commercial space sector to survive and thrive.

While I fully support robust funding for Space Grant Consortiums and other K-12 initiatives, the impact of such funding would be substantially diluted if NASA does not sustain Artemis. Per my testimony, NASA has failed to sustain a beyond LEO human spaceflight program since Apollo. . . until Artemis. Artemis is the first beyond LEO human spaceflight program since the 1960s to successfully make the transition from one partisan Presidential administration to another. Therefore, the most important action that NASA can take to support K-12 education is to show this Nation's students that we're going back to the Moon, this time to stay and, if we can do that, it will inspire a new and robust aerospace workforce.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER WICKER TO
HON. JIM BRIDENSTINE

Government and Commercial Space Partnerships

The John C. Stennis Space Center is home to NASA's largest propulsion and engine test site. It also hosts commercial space companies. NASA increasingly relies on the commercial space sector to execute its mission. At the Center, NASA supports the commercial space industry, including by providing water and chemicals, such as nitrogen and hydrogen.

The One Big Beautiful Bill Act (OBBBA) allocated over \$9 billion for NASA, including \$120 million for infrastructure projects at the Stennis Space Center. Outside of the OBBBA, I introduced the Engine Testing for Exploration Act and the Building Out Optimized Space Testing (BOOST) for Engines Act, which would require NASA to continue rocket propulsion testing at the Stennis Space Center and continue modernization efforts for rocket propulsion test infrastructure at NASA centers.

It is important for the United States government to both grow the commercial space industry and maintain government activity in space, especially as our key competitors, China and Russia, have increased their space presence and developed launch vehicles capable of reaching all orbits and satellite constellations for remote sensing, navigation, and communications.

Question 1. NASA's John C. Stennis Space Center in Mississippi serves as America's largest rocket propulsion test site and exemplifies how NASA can work with commercial space industry. The historic investments in the One Big Beautiful Bill Act will bolster the Stennis Space Center's equities through critical infrastructure improvements and engagement with the commercial space sector. How can we continue to leverage government and commercial partnerships to maximize utilization of NASA centers and achieve our space missions?

Answer. Over the past 70 years, the American people have made great investments in facilities and infrastructure to accomplish space missions. As the entrepreneurial spirit of this country has manifested itself in a robust commercial space industry, we have been able to leverage these capabilities to meet national objectives. If we are going to lean on them to accomplish big things for our country, allowing commercial partners to leverage legacy and new investments at NASA centers is common sense. Stennis Space Center has been a leader in the types of partnerships that facilitate access to NASA facilities and properties.

To ensure maximum utilization Congress should pass legislation that simplifies the processes for companies to gain access to labs and test stands. Simplifying Enhanced Use Leasing authority and transfer of un-utilized property from NASA to an industry partner is also important. While these processes have all improved over the last decade, thanks in part to Senator Wicker's leadership, we still see friction and red tape as industry goes through them, and that should be reduced as much as possible.

Artemis Program

The Artemis Program, announced in 2017, is NASA's mission to return to the moon and prepare for future Mars exploration. The Artemis program emerged from earlier initiatives such as the Constellation program and represents NASA's work on human lunar exploration after a previous focus on the International Space Station (ISS). The spacecraft for the Artemis mission is the Space Launch System rocket (SLS) with an Orion Spacecraft, which will carry humans to the moon. The One Big Beautiful Bill Act included \$4.1 billion for the Space Launch System for Artemis

Missions IV and V. As you know, all engines in the Artemis program are tested at the Stennis Center. Your visits to the Stennis Space Center and its commercial tenants as NASA Administrator highlighted that great work.

Question 2. Why is it important to continue the Artemis program in the wake of the race to the moon with China? What architecture in the Artemis Program needs to change to be able to sustain and replicate missions to the moon?

Answer. After Apollo, we have had too many stops and starts in our attempts to go back to the Moon. Changes in administrations lead to changes in priorities, and previous lunar architectures failed to secure the bipartisan buy-in needed to survive across election cycles. The Chinese government, run by a single authoritarian party, does not have that problem. They can keep their ambitions on track over the time horizons needed to conduct lunar missions.

This is why I am proud of the work we did during my time at the helm of NASA to secure support for the Artemis program. We have now seen it survive two administration changes and multiple shifts in the balance of power in Congress. Ending it now would be devastating, as we would lose the progress we have made—progress that will see America sending astronauts back to orbit the Moon in early 2026—and there is no guarantee any future program could be built to survive across changes in government.

We have a human-rated super heavy lift rocket and we have a human-rated deep space capsule. What we do not have is a lander, and given the time frame that China has stated as their lunar landing goal—before 2030—I believe it is highly unlikely there is anything we could do to beat that timeline.

In the near term, we need to focus on beating them to cislunar space, and we do this by launching the Gateway as soon as possible. If decisions are made right now, it is feasible for the Gateway to be launched to the Moon by 2028. This will allow us to be the first to have permanent human access to cislunar space and provide a platform to closely monitor Chinese surface activity if and when they land. We can also leverage the immense capabilities of industry, through CLPS or other appropriate programs, to begin landing infrastructure and cargo on the surface that will support future human landings.

In parallel, Congress should support the procurement of a human landing system that does not require complex refueling procedures and multiple launches to make it to the Moon. While in-space refueling will be a transformational technology that will enable us to take huge amounts of mass to the surface, it is not the fastest path to the Moon. A simpler system will allow us to not be too far behind China on the next series of landings.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. DAN SULLIVAN TO
HON. JIM BRIDENSTINE

1. Kodiak's Pacific Spaceport: The Arctic Launch Advantage

“Alaska is home to the Pacific Spaceport Complex on Kodiak Island, which offers rare U.S. access to high-inclination and polar orbits. These trajectories are critical for Earth observation, national security, and Arctic monitoring—but they can’t be reached from most U.S. launch sites in the lower 48. Given that China is expanding its launch capability and building Arctic partnerships, how is NASA leveraging Kodiak’s spaceport to ensure secure U.S. launch access into polar orbit? And what investments or partnerships should Congress prioritize to grow this strategic infrastructure?”

Answer. We are already at a point where some of our traditional launch sites that NASA leverages are stretched thin, and the ranges are doing yeoman’s work to find additional capacity but we’re clearly very close to the limit. This problem will be made even worse if decisions are made that allow a singular launch provider at the Cape to essentially shut down operations of every other launcher, including NASA, nearly every day. NASA will need to leverage additional launch sites in this country.

NASA’s Launch Service Program is supposed to encourage a mixed-fleet approach, and this could include launch providers who operate out of Kodiak. Unfortunately, the reality is that NASA’s procurement practices have not aligned with that goal and we are much closer to a monopolistic position.

Congress should limit the amount of launches NASA can award to any one provider in order to promote a robust launch industrial base. There is precedent in the National Security Space Launch program, where Congress has required a minimum amount of launch vehicle diversity to guarantee assured access to space.

2. ASF: NASA's Only SAR Data Center Is in Alaska

"NASA's Alaska Satellite Facility (ASF) at the University of Alaska Fairbanks is the agency's only center for receiving and processing synthetic aperture radar (SAR) satellite data. This data supports disaster response, Arctic monitoring, agriculture, and military logistics, and is critical in cloudy or dark environments—like the Arctic. China and Russia are rapidly advancing SAR satellite capabilities. If NASA moves forward with proposed cuts to ASF, what would be the national and global implications for data continuity, disaster readiness, and Arctic situational awareness?"

Answer. Like space, the Arctic has become an increasingly contested domain, especially as glacier ice has melted and opened new navigation lanes for shipping (and security). There are clear security and economic competitiveness issues at play, and NASA plays a key role. While I appreciate the Administration's focus on human exploration, NASA has a diverse mission set that has direct implications on American dominance. I would encourage Congress to work with the Administration to maintain missions and facilities with clear national implications.

3. Arctic Blind Spots in Navigation and Communications

"Much of the Arctic still lacks reliable satellite-based communications, navigation, and surveillance—gaps that become more urgent as sea lanes open and adversaries increase activity in the region. Alaska's infrastructure could help bridge that gap. What steps is NASA taking—or should it take—in partnership with other agencies, to develop or deploy technologies that support persistent Arctic space-based coverage for communication and navigation? How can we ensure the Arctic doesn't remain a strategic blind spot?"

Answer. Low Earth orbit satellite communications can serve the Arctic, but there must be a competitive market with numerous providers competing on cost and innovation. The FCC should ensure that satellite communications spectrum is not concentrated in one company. Resilient position, navigation, and timing capabilities are being developed by the Department of War through the procurement of commercial PNT in unique orbits utilizing different parts of the electromagnetic spectrum. Resilient PNT and competitive LEO satellite communications will ensure the Arctic is not a strategic blind spot.

4. Poker Flat: The U.S.' Only High-Latitude Rocket Range at Risk

"The Poker Flat Research Range near Fairbanks is the only U.S. sounding rocket range in the high latitudes. It provides low-cost, rapid launch capability for atmospheric and aurora research and supports student training and workforce development. But without renewed NASA investment, it may shut down by 2028. Given the national security implications of Arctic space weather and the affordability of this launch site, what is the rationale for allowing it to atrophy? How does NASA plan to preserve U.S. launch presence in the polar region?"

Answer. The Arctic is an increasingly contested—and important—domain. Any decisions to stand down capabilities in the region should not be taken lightly. Again, NASA has many mission sets that have direct security and dominance implications, and I would encourage the Administration to work with Congress to ensure NASA has a robust budget to continue critical missions and capabilities.

5. Space Weather: Arctic Aviation and Infrastructure Depend on It

"The Geophysical Institute at UAF leads some of the most advanced research in space weather and geomagnetic storms, which pose serious risks to aviation safety, power grids, and communications—especially in the Arctic, where magnetic interference is strongest. With NASA proposing cuts to these programs, what's the potential operational impact on commercial and defense aviation routes over the Arctic? Can the U.S. afford to scale back space weather forecasting in this region when these disruptions are only expected to grow?"

Answer. Space weather forecasting is a topic I have been concerned about since my time in Congress. Solar flares and geomagnetic storms from the sun threaten everything from satellites in orbit and airplanes, to our electrical grid and astronauts in space. The U.S. cannot afford to scale back space weather forecasting, especially in the Arctic.

6. Protecting the STEM Pipeline and National Talent Base

"Alaska institutions like the Geophysical Institute don't just conduct critical research—they also train the next generation of space physicists, engineers, and atmospheric scientists. But NASA's program mergers and delayed awards are already causing labs to lose students and postdocs. How concerned should we be about the long-term loss of this talent pipeline—not just in Alaska but nationally—if funding uncertainty continues to drive students and faculty out of space science fields?"

Answer. I believe the best way to grow the STEM Pipeline is to ensure robust funding across NASA's programs and mission sets, and as part of that funding, for the programs and missions to bring in students to participate meaningfully in mission execution. This gives students real, hands-on operational and flight experience before they enter the workforce. Not only will this be inspiring to those students, it will also make them extremely attractive candidates once it is time for them to seek employment.

7. China's Arctic and Polar Ambitions vs. U.S. Inaction

"China is investing in new polar research bases, satellites optimized for Arctic observation, and even new Arctic shipping routes to advance its space and geopolitical aims. Meanwhile, core Arctic science and space infrastructure in the U.S.—like ASF and Poker Flat—is facing funding cuts or operational risk. What should Congress do right now to make sure the United States doesn't lose its strategic space foothold in the Arctic, particularly when China is aiming to fill any gaps we leave behind?"

Answer. I've previously mentioned my belief that the Arctic has become an increasingly contested domain. Near the end of my time in Congress, as a member of the House Armed Services Committee, we were beginning to pay closer attention to our adversaries' increasing ambitions in the regions. NASA capabilities certainly play a role, but I would recommend the NDAA include provisions that maintain a robust presence in the Arctic.

8. Transparency and Stability in NASA Grantmaking

"Alaska researchers are facing major uncertainty under the new ROSES 2025 program restructures, with some merged solicitations seeing up to 75 percent funding reductions and others marked 'TBD.' These cuts directly impact Arctic science. Should Congress require NASA to provide more transparency and predictability in how these funding lines are combined and awarded? And what safeguards should be considered to protect regionally essential research capacity from being lost in broad program reshuffles?"

Answer. Having served in both the Legislative and Executive Branch, I can assure you that transparency between the branches is critical for our government to function. As a legislator, the only way we can make informed decisions is by receiving adequate information. As a member of the Executive Branch tasked with carrying out programs and initiatives, you want to earn buy-in from the members of relevant Committees in order to gain support for big initiatives.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. TODD YOUNG TO HON. JIM BRIDENSTINE

Question 1. How should Congress think about the balance between funding exploration and science programs to ensure the U.S. retains both technological and geopolitical leadership in space?

Answer. While I understand—and agree with—the Administration's attempts to get our debt and deficit under control, that is not going to be accomplished through the budget of an agency that represents around one third of one percent of the Federal government. Human exploration is and should be a priority, but a robust science budget is critical for American competitiveness. In the first Trump administration, I was proud that the Science Mission Directorate had some of the most robust budgets in NASA's history. I think healthy budgets across NASA's mission sets are key for U.S. leadership.

Question 2. China is rapidly expanding its space science portfolio, positioning themselves to answer fundamental scientific questions before us. What risks does the U.S. face if our cadence of scientific missions within the Science Mission Directorate fails to keep pace with China?

Answer. There is a lot of science that NASA carries out that directly affects how we produce food, produce energy, communicate, navigate, conduct commerce, predict weather, understand climate, and protect hardware and astronauts from space weather. These are key components to American competitiveness and preeminence, and we must maintain our capabilities.

Question 3. NASA plays a unique role in inspiring the next generation of American scientists and recruiting top-class STEM talent from around the world to advance American leadership in space. What steps should NASA and Congress take to ensure these highly skilled individuals remain in the U.S. workforce rather than returning abroad to potentially strengthen our competitors?

Answer. NASA should undertake stunning achievements that inspire workers to stay in the United States.

Question 4. What are your perspectives of China's efforts to develop reusable rockets, and how should the United States compete with that?

Answer. The United States uses and leads in reusable rockets today. However, reusability is not ideal for high energy orbits—the kinds that are preferable for unique, bespoke national security assets. We also lead the world in access to high energy orbits.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
HON. JIM BRIDENSTINE

The Moon Race with China—How do we win

Each of the witnesses during testimony and questioning at the hearing said that winning the race against China to the Moon, not only to land again, but to establish a permanent presence, is vitally important, and each witness expressed varying levels of concern that the U.S. is likely to lose without changes to the current approach. You were especially clear and thorough with your concern about the current Artemis architecture's reliance on the extremely complex and untested Starship lander.

Question 1. Mr. Bridenstine, if we are serious about beating China to the moon and being a first mover when it comes to establishing a sustainable presence in important areas of the lunar surface, what three things do we absolutely need to do as a nation right now from your experience as former NASA Administrator?

Answer. 1) We should accelerate the launch of the Gateway to as early as possible in 2028 in order to be the first country with permanent access to cislunar space; 2) We should explore acquisition models that allow for crew transportation as a service so that Orion does not have to wait for another SLS to take astronauts to the Gateway and puts astronauts at the Moon before China lands, and 3) We should procure a near term landing system that does not rely on in-space refueling and can be ready to take our astronauts from the Gateway to the lunar surface so that we are not far behind on surface presence. As part of this, we should also look at how orbital transfer vehicles can help simplify the Artemis architecture.

Importance of NASA Science, Space Technology, and Aeronautics Funding

NASA's exploration programs depend on steady investment in science and in space technology development, often carried out in partnership with industry.

The President's FY26 budget proposes to cut NASA's Science Mission Directorate by about 47 percent and to reduce the Space Technology Mission Directorate by over 48 percent.

In contrast, the Senate Commerce-Justice-Science proposal restores this funding, protecting the science and technology investments that underpin the Moon-to-Mars strategy and U.S. space leadership.

Question 1. Without robust funding for NASA's science and space technology programs are we ceding our country's long-term space leadership to China and other competitors?

Answer. There is a lot of science and R&D that NASA carries out that directly affects how we produce food, how we produce energy, how we communicate, how we navigate, how we conduct commerce, predict weather, understand climate, protect astronauts and hardware from space weather, and so much more. These are key components to American competitiveness and preeminence, and we must maintain our capabilities.

Question 2. Do you support strong NASA-industry partnerships in the aeronautics sector to advance pre-competitive technologies, such as advanced materials manufacturing? How important are these collaborations for U.S. aerospace competitiveness?

Answer. Yes, the more collaboration between industry and government, especially when industry can bring resources to the table, the better. We know that China is leveraging space and microgravity for advanced materials with a specific focus on hypersonics. NASA and industry should be working together to make sure we stay ahead. A key piece of this is moving forward with Commercial LEO Development, downselecting to two fully mission capable platforms that can be leveraged by both NASA and industry to do exquisite R&D and manufacturing in microgravity.

Additional aerospace collaboration activities that will keep the United States ahead of competitors include: 1) transonic truss-braced wing technology; 2) small core engines for higher bypass ratios; and 3) more electric architectures for propulsion.

Mars Readiness Projections

There is a lot of excitement about sending humans to Mars. But a safe mission will depend on systems we are still developing, including life support for long missions, reliable propulsion for deep space travel, and the equipment needed to live and work on the surface. The Moon gives us a place to test these technologies and prepare.

Before changing the current plan, Congress needs a clear sense of when a safe human mission to Mars will actually be possible.

Question 1. Based on your experience and understanding of current programs, when do you believe a safe and successful human mission to Mars will be feasible?

Answer. I agree with you that the Moon serves as an ideal place to draw down risks and learn lessons for missions to Mars. I also think the Moon serves as a great strategic location for multiple reasons and should be prioritized. Based on this and the current state of technology, I don't think we can attempt a mission to Mars until the 2040s.

NASA Aeronautics Research

NASA's Aeronautics Research Mission Directorate has helped make the U.S. a global leader in aerospace by developing technologies that drive commercial aviation.

But to stay ahead, we must keep investing in innovation. Right now, we're falling behind in a critical area: advanced thermoplastic composites—materials that make aircraft lighter, stronger, and more fuel efficient.

That's why NASA launched the HiCAM project, in partnership with industry, to speed up the development of these materials and apply them to the manufacture of air vehicle components. In my home state of Washington, a consortia of companies, universities, and workforce training organizations are pursuing a Tech Hub to keep the U.S. at the forefront of advanced aerospace manufacturing.

Question 1. You were very supportive of NASA aeronautics research as Administrator—assuming that is still the case, are you comfortable with a 37 percent cut to NASA's aeronautics budget?

Answer. The work done in the Aeronautics Mission Directorate is so critical for American competitiveness, especially as China is making inroads selling airplanes to customers who typically buy from American companies. While I understand—and agree with—the Administration's attempts to get our debt and deficit under control, that is not going to be accomplished through the budget of an agency that represents around one half of one percent of the Federal budget.

Investing in aeronautics has resulted in tremendous economic growth for the United States, which has the effect of reducing deficits.

Designating NASA as a National Security Agency

An August 28 Executive Order titled "Further Exclusions from the Federal Labor-Management Relations Program" reclassified NASA and other agencies as having intelligence or national security as a **primary** function, thereby excluding their employees from collective bargaining rights. This marks a significant departure from NASA's foundational identity, defined by the *National Aeronautics and Space Act of 1958* (P.L. 85-568), as a civilian agency exercising control over aeronautical and space activities sponsored by the United States, distinct from department of Defense activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States). [51 U.S. Code §20102—Congressional declaration of policy and purpose].

Question 1. Are you concerned that there may be unintended consequences of promoting this national security designation for NASA? For example, having a negative impact on the agency's ongoing efforts to pursue the utilization of aeronautical and space activities for peaceful and scientific purposes and pursue cooperation with other nations and groups of nations in the peaceful exploration and use of outer space for civil and commercial purposes?

Answer. The DIME theory states that there are 4 pillars of national power: Diplomatic, Information, Military, and Economic. NASA is relevant to all 4 pillars in various ways.

- D—we partner with other nations on space missions, like the ISS and Artemis, keeping them in our sphere of influence
- I—NASA missions are news around the world. I shared an example of the Insight Lander making the state news of Iran. Not exactly the biggest friend of

ours, and a NASA mission put America in a good light for people who never see the United States in a positive way.

- M—many technologies developed for NASA are dual-use and have applicability for national security purposes.
- E—NASA missions provide data that directly affect our ability to produce food, produce energy, communicate, navigate, transport, and more. NASA plays a major role in U.S. economic competitiveness.

NASA clearly is a key instrument of American power, including national security. However, I do think that it is important for NASA to remain a civil agency focused on exploration, discovery, science, and, especially, diplomacy. The technologies will have natural national security benefits.

NASA Centers Funding in Reconciliation

I want to acknowledge Chair Cruz for his work on ensuring strong funding for NASA human space exploration through the reconciliation process. However, there are aspects of the guidance to NASA in the reconciliation law that I do not support, including the disparity in construction and infrastructure funding contained in the law, with \$1 billion provided to only five centers.

Question 1. Do you believe it is essential that all 10 field centers, their supporting facilities, and the Jet Propulsion Laboratory receive sufficient infrastructure and construction funding to maintain NASA as the world's preeminent aerospace agency?

Answer. It is my understanding that the intent of the reconciliation funding was to focus on human exploration, which is why the centers which received funding were the ones which are primarily focused on that part of NASA's mission.

I do agree with you that there are other critical missions being carried out at other NASA centers and facilities. For example, in the hearing I highlighted the work being done at JPL and the need to maintain the workforce and expertise there. I strongly recommend Congress work through the appropriations process to ensure adequate funding throughout the agency.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO
HON. JIM BRIDENSTINE

Preserving the Science Mission Directorate

NASA's Science Mission Directorate invests in over a hundred space science missions and thousands of scientific research awards. In your testimony, you advocate for the preservation of these investments in space missions and scientific research.

Question 1. Why is it important to maintain investments in this valuable science?

Answer. There is a lot of science that NASA carries out that directly affects how we produce food, how we produce energy, how we communicate, how we navigate, how we conduct commerce, predict weather, understand climate, protect astronauts and hardware from space weather, and so much more. These are key components to American competitiveness and preeminence, and we must maintain our capabilities.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. BEN RAY LUJÁN TO
HON. JIM BRIDENSTINE

Question 1. China has announced not only that they plan on landing on the moon by 2030, but they also want to establish a permanent crewed lunar station by 2035, and an \$11 Billion Earth-Moon economy by 2050. According to the NASA Inspector General last year, SLS will only be able to carry out 1 Orion mission every two years for the foreseeable future. Currently, international partners fly crew to and from the International Space Station about 5 times per year. While a lunar base crew might be smaller to start, could a lunar base be functional with fewer than two missions per year? Will this cadence allow us to build a growing U.S. human presence on the Moon and dominate lunar development and settlement? If not, what frequency would be required?

Answer. I have made it no secret that I think SLS, as the only human-rated super heavy lift rocket, is our only chance to be competitive in the near term. However, I agree that the current cost and throughput of SLS is unsustainable in the long run and I do not think the cadence is enough to allow us to dominate lunar development.

To build a robust surface presence, we will need to procure super-heavy launch commercially from multiple providers—and SLS should have a chance to compete. We should also consider procuring Orion directly as a service. Orbital transfer vehicles should be leveraged to ship supplies to and from cislunar space, and to shuttle landers from the Gateway to low lunar orbit and back.

Near term, SLS represents the best way for us to establish a presence in cislunar space by returning astronauts to lunar orbit for the first time in over 50 years. Long term success will require significant rethinking of the Artemis architecture.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN HICKENLOOPER TO
HON. JIM BRIDENSTINE

Earth Observation Satellites

For years, NASA has developed satellites to monitor our Earth and advance the state of the art in science. NASA has expanded its Earth observation efforts in partnership with commercial companies to procure and democratize access to high-quality datasets of Earth imagery.

During your time leading NASA, partnerships for sharing Earth observation datasets progressed from a small pilot to a sustained Commercial Smallsat Data Acquisition (CSDA) Program.

Question 1. Mr. Bridenstine, how does NASA's scientific research in Earth observation provides benefits not only to the commercial sector, but also advances national security interests and enhances research in academia?

Answer. I have long been a proponent of leveraging commercial data and doing data buys. More data allows for better modeling, prediction, and analysis. Understanding Earth systems such as the cryosphere, the hydrosphere, the lithosphere, atmosphere, and the biosphere are essential to preserving life and property and maintaining competitiveness.

STEM Education

NASA's Office of STEM Engagement funds high impact programs like Space Grant and after-school enrichment. The Colorado Space Grant Consortium brings together 21 colleges, universities, and institutions around our state and connects students to real-world, hands-on NASA projects. The President's Budget Request completely eliminates the Office of STEM Engagement, wiping out Space Grant along with other programs, under the guise of saving money.

Question 2. Mr. Bridenstine, how will the elimination of these kinds of opportunities for our students impact our Nation's ability to provide a skilled workforce that can return humans to the Moon and continue on to Mars?

Answer. I believe the best way to grow the STEM Pipeline is to ensure robust funding across NASA's programs and mission sets, and as part of that funding, for the programs and missions to bring in students to participate meaningfully in mission execution. This gives students real, hands-on operational and flight experience before they even enter the workforce. Not only will this be inspiring to those students, it will also make them extremely attractive candidates once it is time for them to seek employment. I fully support robust funding for this purpose.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN FETTERMAN TO
HON. JIM BRIDENSTINE

The NASA Space Grant funds pre-college and public service education projects in all 50 states, DC, and Puerto Rico, and fills a vital role in preparing the next generation of the space workforce. In Pennsylvania, the Space Grant is operated by Penn State, which leads a consortium of 16 colleges and universities around the commonwealth in space education and research programming in support of the needs of the NASA Mission Directorate.

We know that Chinese universities are training a highly skilled workforce and have built one of the world's most advanced remote sensing space programs. There is bipartisan acknowledgement of the race we are in with respect to space exploration.

Question 1. What actions should U.S. universities take to ensure we remain globally competitive, and how can Space Grant institutions best align with NASA's workforce and research priorities to sustain American leadership in space science and technology?

Answer. We have seen many examples of universities who have led NASA missions come in on time and under budget. I think more universities should seek to

prime contracts versus being part of a team. I also think NASA should make adjustments to its acquisition processes to provide more opportunities for university-led missions. On top of saving money and executing missions on time, university-led missions will have significant student involvement, providing experience for a future workforce that can enter NASA or the space industry after school.

Question 2. What steps should Congress take to ensure that NASA's reauthorization provides the long-term stability and investment universities need to contribute fully to U.S. leadership in space, especially as adversaries seek to set their own rules of the road?

Answer. Congress should consider setting a requirement when awarding missions that the winning contractor should include some level of direct student involvement in mission development, production, integration, operations, and/or analysis. Additionally, along the lines of my previous answer, Congress could require a certain percentage of missions to be university-led.

Question 3. What are the risks to our existing workforce pipeline if funding for NASA Space Grants or similar K-12 STEM program is interrupted, withheld, or reduced?

Answer. In my view, students in primary and secondary school are inspired to enter STEM fields when they see NASA accomplish big, stunning achievements. NASA should have a robust budget to undertake these efforts that get kids excited about STEM fields, and those achievements should be properly communicated by NASA so that kids can learn about them.

Once we get into post-secondary education, that is where missions should be bringing in direct student involvement, perhaps even being required by Congress to have direct student involvement. Funding NASA across its mission portfolio and bringing in students from universities across the country into those missions will significantly bolster our STEM workforce pipeline.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. ROGER WICKER TO
LT. GEN. JOHN SHAW

Government and Commercial Space Partnerships

The John C. Stennis Space Center is home to NASA's largest propulsion and engine test site. It also hosts commercial space companies. NASA increasingly relies on the commercial space sector to execute its mission. At the Center, NASA supports the commercial space industry, including by providing water and chemicals, such as nitrogen and hydrogen.

The One Big Beautiful Bill Act (OBBBA) allocated over \$9 billion for NASA, including \$120 million for infrastructure projects at the Stennis Space Center. Outside of the OBBBA, I introduced the Engine Testing for Exploration Act and the Building Out Optimized Space Testing (BOOST) for Engines Act, which would require NASA to continue rocket propulsion testing at the Stennis Space Center and continue modernization efforts for rocket propulsion test infrastructure at NASA centers.

It is important for the United States government to both grow the commercial space industry and maintain government activity in space, especially as our key competitors, China and Russia, have increased their space presence and developed launch vehicles capable of reaching all orbits and satellite constellations for remote sensing, navigation, and communications.

Question 1. NASA's John C. Stennis Space Center in Mississippi serves as America's largest rocket propulsion test site and exemplifies how NASA can work with commercial space industry. The historic investments in the One Big Beautiful Bill Act will bolster the Stennis Space Center's equities through critical infrastructure improvements and engagement with the commercial space sector. How can we continue to leverage government and commercial partnerships to maximize utilization of NASA centers and achieve our space missions?

Answer. The John C. Stennis Space Center (which I had the privilege to visit during my military career) is a national treasure that should continue to be a centerpiece of rocket development for the Nation. I would support NASA efforts to incentivize commercial companies to more actively leverage Stennis (and other NASA centers) through more aggressive public-private partnerships to better share risk but also harness the engines of commercial innovation.

Beating China in Space

The development of the People's Republic of China's (China) civilian and military space programs over the last few decades has proceeded alongside its broader rise in the international system. China is rapidly advancing its activity in space to land

astronauts on the Moon by 2030 and establish dominance in space. On August 15, 2025 China completed a ground test of the first-stage propulsion system of its new rocket, the Long March 10, to send people to the moon. China is also developing a variant launcher to send astronauts to its space station. The country is running other tests for crewed spacecrafts.

China is heavily investing in other research and development programs to increase its space technology and capabilities. China's successes in space are significant and notable achievements include crewed space platforms, reliable space launch vehicles and satellites, and landing a lunar probe on the far side of the moon. China's space ambitions are inherently dual-use in nature: it would like to increase its civilian technological capabilities and build up its military space program to advance its strategic interests.

Question 2. Lt. Gen. Shaw, the Chinese Communist Party (CCP) is executing a long-term strategy to exploit U.S. capabilities to build up its space programs and advance its strategic interests at the expense of the United States. What actions does the United States need to take to beat China to the moon and deter China from truly achieving space dominance?

Answer. As I mentioned in my testimony, we need a unified grand space strategy of our own, to match China's. Our national (both government and commercial) space endeavors in the Earth-Moon system as projected over the next decade are not synchronized and lack the synergy that could be gained by harnessing civil, national security, and commercial in a more integrated manner. An example is lunar space domain awareness. We will need such capabilities to sustain a human presence in the lunar environment (whether in lunar orbit, on the lunar surface, or both) but no organization—govt or commercial—is actively pursuing a lunar domain awareness architecture in a strategic manner.

One possible approach (among many options) to remedying this would be for Congress to commission a bipartisan blue ribbon panel to propose the framework for such a unified strategy, to include recommendations for both the Executive and Legislative branches for implementation.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. DAN SULLIVAN TO
LT. GEN. JOHN SHAW

1. Kodiak's Pacific Spaceport: The Arctic Launch Advantage

"Alaska is home to the Pacific Spaceport Complex on Kodiak Island, which offers rare U.S. access to high-inclination and polar orbits. These trajectories are critical for Earth observation, national security, and Arctic monitoring—but they can't be reached from most U.S. launch sites in the lower 48. Given that China is expanding its launch capability and building Arctic partnerships, how is NASA leveraging Kodiak's spaceport to ensure secure U.S. launch access into polar orbit? And what investments or partnerships should Congress prioritize to grow this strategic infrastructure?"

Answer. First, I was privileged to visit Alaska many times in my military career, mostly to inspect bases and capabilities for which I was responsible (*e.g.*, Clear AFS, Ft Greeley). Alaska has much to offer our Nation's space endeavors across the spectrum of missions.

I am not deeply knowledgeable about NASA's current leveraging of Kodiak's spaceport. But I firmly believe our Nation needs *far more* space launch sites than it currently has, for industrial capacity, resilience, and redundancy, particularly in wartime. Alaska's Kodiak spaceport should be a high priority for whole-of-nation investment and use for all of these reasons.

2. ASF: NASA's Only SAR Data Center Is in Alaska

"NASA's Alaska Satellite Facility (ASF) at the University of Alaska Fairbanks is the agency's only center for receiving and processing synthetic aperture radar (SAR) satellite data. This data supports disaster response, Arctic monitoring, agriculture, and military logistics, and is critical in cloudy or dark environments—like the Arctic. China and Russia are rapidly advancing SAR satellite capabilities. If NASA moves forward with proposed cuts to ASF, what would be the national and global implications for data continuity, disaster readiness, and Arctic situational awareness?"

Answer. I am proud to have worked on Synthetic Aperture Radar systems during my military career. Synthetic Aperture Radar data and products are, in my view, ripe for a new level of exploitation (perhaps even a revolution) with the rise of some Artificial Intelligence methodologies that can analyze SAR data in ways and at speeds/scales that humans cannot. As suggested in the questions, such new exploi-

tation can benefit a wide spectrum of human activities and fields of analysis, including Arctic situational awareness and much more. Given this looming opportunity, the government must encourage continued interest and investment in this sector, whether it is NASA or other govt organizations that help unlock new civil and commercial applications.

3. Arctic Blind Spots in Navigation and Communications

“Much of the Arctic still lacks reliable satellite-based communications, navigation, and surveillance—gaps that become more urgent as sea lanes open and adversaries increase activity in the region. Alaska’s infrastructure could help bridge that gap. What steps is NASA taking—or should it take—in partnership with other agencies, to develop or deploy technologies that support persistent Arctic space-based coverage for communication and navigation? How can we ensure the Arctic doesn’t remain a strategic blind spot?”

Answer. From my time as Deputy Commander of U.S. Space Command and my close collaboration with U.S. Northern Command, I am familiar with the challenges of awareness and operating in the increasingly busy Arctic (both U.S. Space Command and U.S. Northern Command have considerable mission responsibilities in the Arctic). The Department of Defense is pursuing some solutions to these challenges, but a unified whole-of-government approach that includes NASA (and NOAA and others) would be better. I would encourage NASA to work with the DoD on this approach and bring the right expertise and resources to bear to assist in this strategic area.

4. Poker Flat: The U.S.’ Only High-Latitude Rocket Range at Risk

“The Poker Flat Research Range near Fairbanks is the only U.S. sounding rocket range in the high latitudes. It provides low-cost, rapid launch capability for atmospheric and aurora research and supports student training and workforce development. But without renewed NASA investment, it may shut down by 2028. Given the national security implications of Arctic space weather and the affordability of this launch site, what is the rationale for allowing it to atrophy? How does NASA plan to preserve U.S. launch presence in the polar region?”

Answer. Similar to Kodiak, Poker Flat offers additional capacity, resilience, and redundancy in our access to space and near-space—all of which are increasingly needed. I would encourage NASA to work with the DoD on this approach and bring the right expertise and resources to bear to assist in this strategic area.

5. Space Weather: Arctic Aviation and Infrastructure Depend on It

“The Geophysical Institute at UAF leads some of the most advanced research in space weather and geomagnetic storms, which pose serious risks to aviation safety, power grids, and communications—especially in the Arctic, where magnetic interference is strongest. With NASA proposing cuts to these programs, what’s the potential operational impact on commercial and defense aviation routes over the Arctic? Can the U.S. afford to scale back space weather forecasting in this region when these disruptions are only expected to grow?”

Answer. I hope and expect the cuts we have seen to NASA’s science research and space technology programs are temporary. I would also hope to see more consistent and comprehensive focus in these programs in the future, all pursued in an integrated and connected fashion to get after the strategic challenges and opportunities we see in space (such pursuits have NOT always been integrated and connected in the past).

6. Protecting the STEM Pipeline and National Talent Base

“Alaska institutions like the Geophysical Institute don’t just conduct critical research—they also train the next generation of space physicists, engineers, and atmospheric scientists. But NASA’s program mergers and delayed awards are already causing labs to lose students and postdocs. How concerned should we be about the long-term loss of this talent pipeline—not just in Alaska but nationally—if funding uncertainty continues to drive students and faculty out of space science fields?”

Answer. Again, I hope and expect the delays and cuts we have seen to NASA’s science research and space technology programs are temporary. As an engineer myself, I believe we should absolutely be concerned about *any* circumstance where our technical competitive advantage vis à vis the rest of the world, particularly our adversaries, is eroded. We are already far behind China in quantity/numbers of engineers and other STEM-related fields that graduate from universities every year. Quality of that talent is harder to measure though I expect the United States still has the edge, but numbers have a quality all their own. . .

7. China's Arctic and Polar Ambitions vs. U.S. Inaction

"China is investing in new polar research bases, satellites optimized for Arctic observation, and even new Arctic shipping routes to advance its space and geopolitical aims. Meanwhile, core Arctic science and space infrastructure in the U.S.—like ASF and Poker Flat—is facing funding cuts or operational risk. What should Congress do right now to make sure the United States doesn't lose its strategic space foothold in the Arctic, particularly when China is aiming to fill any gaps we leave behind?"

Answer. Our big-picture approach to facilities—from research/development to operational—should be a key part of a unified grand space strategy. If we have sound strategic objectives in that arena, then the ways/means (who, what, where), whether civil, commercial, or national security, can be better focused and synchronized. Congress should endorse such a strategy, perhaps by (but not limited to) commissioning a bipartisan blue ribbon panel to propose the framework for such a unified strategy, to include recommendations for both the Executive and Legislative branches for implementation.

8. Transparency and Stability in NASA Grantmaking

"Alaska researchers are facing major uncertainty under the new ROSES 2025 program restructures, with some merged solicitations seeing up to 75 percent funding reductions and others marked 'TBD.' These cuts directly impact Arctic science. Should Congress require NASA to provide more transparency and predictability in how these funding lines are combined and awarded? And what safeguards should be considered to protect regionally essential research capacity from being lost in broad program reshuffles?"

Answer. Yes, I believe Congress should request that of NASA. And as part of that request, ask for the strategic approach that weighs the value of all research capacity, wherever it is, as it contributes to focused, strategic goals.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY MARIA CANTWELL TO
LT. GEN. JOHN SHAW

The Moon Race with China—How do we win

Each of the witnesses during testimony and questioning at the hearing said that winning the race against China to the Moon, not only to land again, but to establish a permanent presence, is vitally important, and each witness expressed varying levels of concern that the U.S. is likely to lose without changes to the current approach.

Question 1. General Shaw, if we are serious about beating China to the moon and being a first mover when it comes to establishing a sustainable presence in important areas of the lunar surface, what three things do we absolutely need to do as a nation right now?

Answer. First, we should begin to develop and pursue the unified grand space strategy I described in my Prepared Statement and during my testimony. NASA—by itself and with only its budget—is highly unlikely to keep pace with China on a sustained human and autonomous presence in and around the moon. The Apollo program was not just NASA—it was an effort across the U.S. government and beyond.

Second, we need to get accurate assessments of the current status of all of the architectural pieces needed for a sustained lunar presence. Some (such as lunar space domain awareness and lunar communications, as I mentioned in my testimony) appear to me to be woefully behind where they need to be. Once a holistic assessment is in place, a clear-headed campaign plan can be put in place to align the total architecture.

Third, we need to explore more creative ways of pursuing public-private partnerships to achieve the objectives of the above needs. NASA has tremendous symbolic influence and an abundance of soft power. I expect there are many actors that would relish being a part of NASA-led efforts, and would accept value propositions that vary widely from traditional contractual arrangements. It is time to leverage and exploit these possibilities. . . .

Importance of NASA Science, Space Technology, and Aeronautics Funding

NASA's exploration programs depend on steady investment in science and in space technology development, often carried out in partnership with industry.

The President's FY26 budget proposes to cut NASA's Science Mission Directorate by about 47 percent and to reduce the Space Technology Mission Directorate by over 48 percent.

In contrast, the Senate Commerce-Justice-Science proposal restores this funding, protecting the science and technology investments that underpin the Moon-to-Mars strategy and U.S. space leadership.

Question 1. Without robust funding for NASA’s science and space technology programs are we ceding our country’s long-term space leadership to China and other competitors?

Answer. I hope and expect the cuts we have seen to NASA’s science and space technology programs are temporary. I would also hope to see more consistent and comprehensive focus in these programs in the future, all pursued in an integrated and connected fashion to get after the strategic challenges and opportunities we see in space (such pursuits have NOT always been integrated and connected in the past). If we do this, I expect we will sustain our long-term space leadership.

Question 2. Are there specific areas of technology where we already lag behind China that NASA should prioritize now?

Answer. Absolutely. We need to develop a unified strategy (across civil, commercial, and national security) to pursue a robust in-domain logistics infrastructure within the Earth-Moon system, as well as an integrated lunar space domain awareness architecture.

Mars Readiness Projections

There is a lot of excitement about sending humans to Mars. But a safe mission will depend on systems we are still developing, including life support for long missions, reliable propulsion for deep space travel, and the equipment needed to live and work on the surface. The Moon gives us a place to test these technologies and prepare.

Before changing the current plan, Congress needs a clear sense of when a safe human mission to Mars will actually be possible.

Question 1. Based on your experience and understanding of current programs, when do you believe a safe and successful human mission to Mars will be feasible?

Answer. I am personally enthusiastic about human missions to Mars and I sincerely hope I will see those happen in my lifetime!

As a lifelong engineer, I foresee many different capabilities that will need to come together in a unified way to make a truly robust human mission to Mars possible, and even more for a permanent human presence on Mars.

If we pursue a unified grand space strategy that coordinates and synchronizes civil, commercial and nation security efforts towards common goals, a sustainable human mission to Mars is possible by 2040.

NASA Aeronautics Research

NASA’s Aeronautics Research Mission Directorate has helped make the U.S. a global leader in aerospace by developing technologies that drive commercial aviation.

But to stay ahead, we must keep investing in innovation. Right now, we’re falling behind in a critical area: advanced thermoplastic composites—materials that make aircraft lighter, stronger, and more fuel efficient.

That’s why NASA launched the HiCAM project, in partnership with industry, to speed up the development of these materials and apply them to the manufacture of air vehicle components. In my home state of Washington, a consortia of companies, universities, and workforce training organizations are pursuing a Tech Hub to keep the U.S. at the forefront of advanced aerospace manufacturing.

Question 1. How critical is on-shoring advanced aerospace manufacturing technologies to advancing U.S. economic and national security?

Answer. I am more familiar than most with the aerospace industry and manufacturing ecosystem in Washington State—I completed my graduate work in aerospace control theory at the University of Washington, leveraging many local aerospace efforts for my research and case studies during my time there. As the number of engineers and scientists our competitors produces each year increases and eclipses our own, it is increasingly critical we maintain the global lead in this and other technology sectors.

Designating NASA as a National Security Agency

An August 28 Executive Order titled “Further Exclusions from the Federal Labor-Management Relations Program” reclassified NASA and other agencies as having intelligence or national security as a **primary** function, thereby excluding their employees from collective bargaining rights. This marks a significant departure from NASA’s foundational identity, defined by the *National Aeronautics and Space Act of 1958* (P.L. 85–568), as a civilian agency exercising control over aeronautical and space activities sponsored by the United States, distinct from department of Defense

activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States). [51 U.S. Code § 20102—Congressional declaration of policy and purpose].

Question 1. Are you concerned that there may be unintended consequences of promoting this national security designation for NASA? For example, having a negative impact on the agency's ongoing efforts to pursue the utilization of aeronautical and space activities for peaceful and scientific purposes and pursue cooperation with other nations and groups of nations in the peaceful exploration and use of outer space for civil and commercial purposes?

Answer. I do think there are significant elements within NASA and pursuits by NASA that have national security implications and applications, and I do not believe you can completely sever NASA from the United States' national security focus and objectives. This would go against my proposed unified grand space strategy.

That said, I am not privy to the current administration's policy thinking on this Executive Order.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. BEN RAY LUJÁN TO
LT. GEN. JOHN SHAW

Question. Thank you for your opening statement regarding a unified space strategy to coordinate civil, commercial, and national security efforts. I share your enthusiasm for modernizing how the Federal government works with private sector companies to promote agility and enable innovation. I've been happy to co-lead several bipartisan bills aimed at this topic. The U.S. military increasingly relies on commercial partnerships for communication and intelligence, yet we don't have a coherent strategy on how to best harmonize the public and private interests. Given your experience on both the defense and private side, what are the biggest barriers to these partnerships? What can Congress do to ensure both parties' interests are well-served?

Answer. First, as I answered to Sen Cantwell's question, we need to explore more creative ways of pursuing public-private partnerships to achieve mission objectives of the above needs. The Dept of Defense also, in addition to NASA, has tremendous symbolic influence and an abundance of soft power. I believe there is substantial capital available to contribute toward innovative value propositions that vary widely from traditional contractual arrangements.

Also, the U.S. government could improve the way it signals interest and potential commitment to commercial providers as they demonstrate and develop capability. An example of this is the National Security Space Launch contracting approach of multiple "lanes" and providers. As launch companies demonstrate capability, they can be onboarded into initial lanes, and then, as they demonstrate more capability and maturity, move to higher lanes of greater value and national security importance. This approach helps to bridge that "valley of death" that many commercial companies fall into with current approaches.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN HICKENLOOPER TO
LT. GEN. JOHN SHAW

Access to Spectrum

Space is an increasingly contested domain that requires 24/7 vigilance. To enhance communications, civil space agencies (NASA, NOAA) and our national security leaders across the DOD rely on access to spectrum to perform key functions such as transmitting mission critical alerts, capturing high-resolution imagery, and operating advanced radar systems.

Question 1. Lt. Gen. Shaw, do you believe it is essential that civil space and national security agencies maintain reliable access to spectrum without harmful interference?

Question 2. Lt. Gen. Shaw, do you have any concerns about the potential interference to Federal missions as a result of new timelines and targets authorized by Congress to auction Federal spectrum to commercial users?

Answer 1. In short, absolutely, some sections of the electromagnetic spectrum should be prudently reserved for government use.

I have observed throughout my military career the impact of ever-present unintentional electromagnetic interference on military operations—even when spectrum boundaries are relatively clear with sufficient guard bands. We risk an ever-increas-

ing interference environment without some measure of spectrum protection for civil and national security uses. I believe the spectrum carve-outs in the GHz bands in the 2025 reconciliation bill were prudent and *necessary* measures—they may not, however, have been *sufficient* for the long term.

Answer 2. In short, I do have concerns. I support the ability of the FCC to have the right authorities to auction spectrum in a forward-thinking and fully-informed way that encourages innovation and drives economic growth. But this needs to be done in a thoughtful, coordinated fashion acknowledging current and future government needs.

