

**EXAMINING NASA'S FY24 BUDGET
AND PRIORITIES**

HEARING

BEFORE THE

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

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

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EXAMINING NASA'S FY24 BUDGET AND PRIORITIES

TUESDAY, MAY 16, 2023

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

The Committee met, pursuant to notice, at 10 a.m., in room SR-253, Russell Senate Office Building, Hon. Maria Cantwell, presiding.

Present: Senators Cantwell (presiding), Sinema, Rosen, Luján, Hickenlooper, Cruz, Wicker, Blackburn, Budd, and Schmitt.

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

The CHAIR. The Committee on Commerce, Science, and Transportation will come to order.

For more than—the hearing this morning is going to be examining NASA's Fiscal Year 2024 Budget and Priorities, and discussions of that.

For more than 100 years, the National Aeronautics and Space Administration and its predecessor agency, the National Agency Advisory Committee on Aeronautics, have delivered on its commitment to make the United States of America a world leader in aviation and space. I am not sure how many know about the deep connection between NASA and the aviation industry, but there is a saying at the Agency, "NASA is with you when you fly." When many of the aircraft roll off the line in Everett, Washington, they have a quieter and cleaner engine technology developed and tested, thanks to at least two NASA programs. So NASA has long been an important partner to the development of the 2 million strong American aviation and defense sector jobs.

When it comes to space exploration, the scientific research, NASA has also been equally powerful. In 2022 alone, NASA delivered the first images from the James Webb Telescope and demonstrated the space launch system, an Orion crew vehicle that will send the first woman to the moon. The NASA DART mission even proved for the first time that this country could defend itself from a planet-killing asteroid, and every single one of these stories made national news. Two of them have close ties to the Washington State workforce. Workers in Redmond, Washington built part of the propulsion system for both the space launch system and the DART mission, and we also have several scientists who have been assigned research time on the Webb Telescope.

But as a Congress, we cannot afford to take NASA and its success for granted. That is why this committee in the reauthorization of the Agency last year, was a critical part of the CHIPS and Science Act. This was the first NASA authorization in 5 years. Now, we might say it is because our colleague is no longer with us, who was a key advocate for always getting NASA authorized. But we authorized the Artemis Program and demanded that NASA establish both accountable leadership and a clear description of each element in the effort in response to concerns raised in the hearing by the head of the National Aerospace Safety Advisory Panel.

We directed the Agency to create an independent program analysis, evaluation office, reduce the cost of delays associated with programs, and also, in response, raised concerns in this hearing this time by the Government Accountability Office. And we made it the policy of the United States to maintain world leadership in aeronautics by advancing such areas as advanced materials and manufacturing. Over the course of this hearing, I look forward to hearing from the Administrator about the progress of these particular areas.

It is my goal to complete another NASA bill this Congress, this time with a multi-year authorization that will help ensure that the Nation's leading space and aeronautic research agency has stable, predictable funding that it needs to succeed. It would be the first multi-year NASA authorization in 13 years.

It should be clear to every Member of Congress we cannot operate our science agencies on the cheap, and we should not operate them without clear, multi-year direction. Stable growing investments in the technologies of the future, from hypersonic wind tunnels to advanced manufacturing, are the best way to protect our national and economic security. Given NASA anything less could jeopardize our leadership in space exploration, slow down our progress on key issues as faster fuel efficiency, increase the challenges that we face at our space station, and jeopardize commonsense safety actions, like building redundant systems to transport astronauts.

Administrator Nelson has been a tireless advocate to protect NASA's budget, so I look forward to working with him and Ranking Member Cruz to make sure that NASA and the United States keep their leadership position. So thank you for joining us today, Administrator Nelson, and now I turn it over to my colleague, Senator Cruz, for his statement.

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

Senator CRUZ. Thank you, Madam Chair. Good morning. I suppose we should begin with a moment of regret. You and I had a wager going about the Kraken and the Stars, and last night as these wagers, we bid on winning sides and losing sides of the wagers. But I will say I look forward to some wonderful delicacies from Washington State as we celebrate the Star's game seven victory last night.

The CHAIR. Well, congratulations, Senator Cruz. At least—I told him he should up on time if he wants to gloat, but it is OK.

[Laughter.]

The CHAIR. We are very proud of the Kraken. Congratulations to the Stars, and, yes, some great salmon is coming your way, and I think some beer, OK?

Senator CRUZ. Fabulous.

The CHAIR. OK.

Senator CRUZ. Good morning. Administrator Nelson, welcome back to this committee. All of us have spent a lot of time here. You and I have been great partners on many pieces of space legislation, and thus far, your tenure as NASA Administrator has seen a number of important successes. Today I am looking forward to hearing an update on all things space.

First, I think it is fitting to open with a note of congratulations to NASA and its international and commercial partners throughout the United States and the world, especially those partners in Texas, for all your recent successes. Like many Americans, I watched with excitement as Artemis I blasted off into space as the first phase of America's return to the moon. I am thrilled that NASA has named the crew of the Artemis II mission—Reid Wiseman, Victor Glover, Christina Koch, Jeremy Hansen—and I was incredibly privileged to be with you at Ellington Field in Houston for that announcement. Over the next year, they will complete their training at the Johnson Space Center for their 2024 flight to the moon.

We were all equally excited about the recent test launch of SpaceX's Starship—from their Starship in Boca Chica, Texas. While the "rapid unscheduled assembly" was not exactly part of the plan, much was learned just getting off the pad, and we look forward to SpaceX launching again soon. Once again, Starship will help us return American boots to lunar soil for the first time in more than 50 years on the Artemis III mission.

There is a reason the word "Houston" was one of the very first words spoken on the surface of the moon and why it is one of the most common words in any astronaut's vocabulary. Johnson Space Center in my hometown of Houston is responsible for carrying out many key missions for space exploration. Not only is it the home of the International Space Station Program, which I was glad after years of fighting for it, that you and I together were finally able to extend it to 2023. But it is also home to Mission Control and is playing a leading role in our efforts to put a sustainable human presence on the moon, and eventually put the first humans on the surface of Mars. From the Gateway Lunar Outpost, to the Orion capsule, to the next generation of space suits, to future lunar rovers, JSC is leading the way. As a lifelong Houstonian, I am so proud of the entire team at JSC and of the entire Houston space community.

This year's budget request includes even more funding for new space suits developed by Collins Aerospace and Axiom, and will help our astronauts ensure that they are safe and productive on the ISS, on the moon, and beyond. These two companies are just many—that will make the new Houston space port a magnet for those who wish to help us explore the stars.

Now, Administrator Nelson, for all the good things I have talked about, I do worry sometimes that we may be losing focus on what makes America the preeminent space-faring Nation. One of the

reasons you and I were able to accomplish so much on this committee is both of us worked very hard to keep politics out of NASA and to focus on the core mission of exploration. Looking at this year's budget request, I see things like \$22 million for the "Office of Diversity and Equal Opportunity," which has little to do with what you have called "a space race between the free world and China." If we show up at the Shackleton Crater, I highly doubt the communist—Chinese Communist Party will care much about how we have advanced an equity action plan.

Similarly, this year, NASA, along with DOD and GSA, advanced a new climate-related regulation that requires contractors to disclose their "greenhouse gas emissions, the risks they pose, and submit reduction targets validated by Science-Based Targets initiative," a non-governmental entity. Rather than helping us win the space race, the proposed rule would ensure that NASA could do less exploration and less science for more taxpayer dollars.

Earlier this year, every one of my Republican colleagues on this committee joined me in sending a letter to you asking you to rescind the proposed rule. Your response to the letter was, unfortunately, underwhelming. I suspect that had you received such an answer when you were sitting on this committee, you would not have been especially pleased. I understand that any NASA faces pressure and political pressure from a White House. That was true in the prior administration. That is true in this administration. But one of the keys, I believe, for NASA's success is having the fortitude to press back on political pressure from either direction and to focus on the core mission. I very much hope at NASA we can continue to do so and continue to do so together.

The CHAIR. Thank you, Senator Cruz. We will now turn to the Chair of the Subcommittee and the Ranking Member for their opening statements. And I have asked Senator Sinema to chair the rest of this hearing, and so thank you, Senator Sinema, for your leadership on space issues.

**STATEMENT OF HON. KYRSTEN SINEMA,
U.S. SENATOR FROM ARIZONA**

Senator SINEMA. Well, thank you, Chair Cantwell. Good to see you again, Administrator Nelson. I am honored to chair the Space and Science Subcommittee where I am proud to continue the leadership that led to the bipartisan passage of the CHIPS and Science Act last Congress. I look forward to building on those historic advancements and achieving America's space and science goals.

NASA has a tremendous impact on my home State of Arizona, accounting for over \$700 million and over 3,800 jobs in Fiscal Year 2021, and that doesn't account for all the manufacturing, contract work, and growing commercial space, industries that are all strengthened by NASA's work. Ultimately, American leadership in space is critical to keeping us safe, building a healthy economy, and serving as an engine to fuel rewarding careers.

For the United States to remain the global leader in space, we need to ensure that Congress makes the necessary investments. That starts with NASA's initiatives in planetary defense, space exploration, earth and space science research, and advancing aeronautic and other technologies.

There are few roles of government more important than planetary defense, and I am proud of Arizona's outsized contribution to confronting these challenges by playing a leading role in the NEO Surveyor and NEOWISE missions, helping to equip the planet against potentially harmful space objects and debris. It is absolutely essential that Congress fund the NEO Surveyor Program as requested in the Fiscal Year 2024 budget request and at the appropriate levels for years to come as we approach the 2028 launch date.

NASA's research is no less vital than its planetary defense missions. The State of Arizona is a vital contributor to space physics, astrophysics, and other studies through Arizona State University and University of Arizona. Both universities has successfully supported NASA science missions for decades and provide a strong pipeline for future scientists and engineers to start careers in government and commercial space. That is why our work on the CHIPS and Science Act ensured NASA's reauthorization and incorporated provisions I helped draft to direct NASA to fund key science research at Arizona's universities. We must continue to provide resources to these and other leading institutions.

The scientific research NASA leads, including through the Earth Information Center and other data-related initiatives, benefits Arizonans and all Americans right now, not theoretically in the future. NASA is a critical part of efforts to combat difficulties Arizona families face every day from water scarcity to extreme weather events and beyond.

Space is no longer the exclusive domain of the Federal Government. Commercial space has invested heavily in Arizona, from Artemis manufacturing to the innovative new space program at Arizona State University. And just last month, Blue Origin recently opened a Phoenix office, specializing in avionics, systems engineering and supply chain management. This follows the opening of a Virgin Galactic manufacturing facility in Mesa last year, and expansion of existing facilities for Boeing and Northrop Grumman in recent years.

It is absolutely essential that NASA has the resources to be an effective industry partner and that we continue to grow a thriving commercial space industry. Success in commercial space means American leadership and a center for rewarding careers. Those careers must be open to all, and this means making the right investments in STEM education. Finally, NASA needs the resources to hire and maintain a world-class workforce which, in turn, requires physical infrastructure. It is our job in Congress to ensure that the taxpayer money is spent wisely, and we must, therefore, be critical and ask the necessary questions to any budget request. But the responsibility to spend taxpayer money wisely also means that we are making sure the money is, in fact, spent where it must to help keep us safe, secure, and promote a healthy economy with rewarding careers.

I look forward to asking Administrator Nelson questions today and working with NASA this Congress to continue helping Arizona and the American people. Thank you, Madam Chair. I yield back.

The CHAIR. Senator Schmitt. Thank you.

**STATEMENT OF HON. ERIC SCHMITT,
U.S. SENATOR FROM MISSOURI**

Senator SCHMITT. Thank you, Madam Chair, and thank you, Administrator Nelson, for joining us here today. It is great to be with you in this committee on this hearing focused on space, NASA, and exploring the final frontier. The story of Missouri is intimately tied to the exploration of the stars. Famous astronomer, Edwin Hubble, was born in Marshfield, Missouri, and the telescope dedicated in his name has forever changed our understanding of the universe. As ranking member of the Science—or the Space and Science Subcommittee, I look forward to working with you to progress the priorities of this committee. Of those, the one in front of us here today is NASA’s reauthorization, and I am eager to work in a bipartisan fashion with you and the full committee chair and ranking member to hopefully get that across the finish line.

Here in the United States, we are privileged to have a robust commercial supplier base at the foremost space flight companies in the world. Over 20 Missouri-based companies, from Joplin to Hazelwood, are actively supporting the Artemis mission to return man to the moon. As Ranking Member of the Space and Science Subcommittee, I want to do everything in my power to leverage the abilities of innovation that U.S. companies possess to maintain American space dominance. It is imperative that the U.S. and the appropriate agencies develop thoughtful, commonsense standards when it comes to the development and deployment of technologies related to orbital debris management, commercial space stations and other deep space waypoints, hypersonics, human landing systems, and the numerous other technologies necessary to get us back to the moon and beyond to Mars.

I cannot emphasize enough—I cannot emphasize this enough. So much of this developing technology is just that, developing. Sadly, the default approach around this town, in my view, is what more can the government do, not less innovation thriving under the light torch of regulation, not the heavy hand of government. While I still have not—while I still have a lot to learn in this space—no pun intended—I, along with my staff, continue to hear from industry about how knee-jerk and untenable regulations have stymied U.S. leadership. This should not be anybody’s goal, especially as foreign adversaries seek to undermine our efforts at every corner. On that note, I want to speak about the near and present danger of China. China’s capabilities in space and beyond is alarming.

Madam Chair, I would like to submit the following articles entitled, “A Chinese Spacecraft Has Been Checking Out U.S. Satellites High Above Earth,” and “China Building Cyber Weapons to Hijack Energy Satellites, Says U.S. Leak,” which highlight the ability of the CCP multi-directional satellites to stop and gather intel on U.S. space equities, and “The CCP’s Development of Cyber Weapons to Seize Control of U.S. Space Equities.”

While I commend the Administrator for the many initiatives he will highlight in his testimony, I strongly disagree with this administration’s obsession with misguided woke policies related to climate change and diversity, equity, and inclusion. Administrator Nelson, America cannot afford to take its eye off the ball with the rising threat of the CCP. There is simply too much at stake. Presi-

dent Xi and the CCP are hell-bent on dominating us on every front. We must be laser-like focused on our approach, and I can assure you that China has no interest in out de-eying us, and they are not intimidated at all by this divisive radical policy that has found its way in this budget.

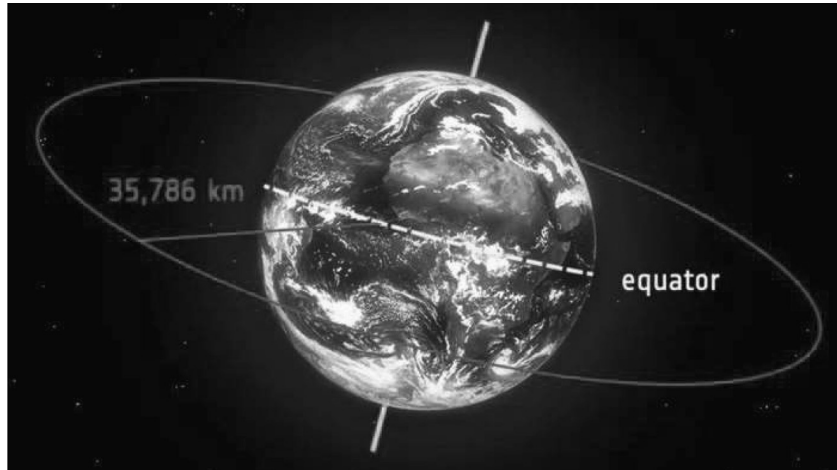
Madam Chair, thank you again for convening this hearing, and thank you to Mr. Nelson for appearing before us today. I look for today's hearing and the proceedings. I yield back. Thank you.

The CHAIR. Thank you, and without objection, we will enter those articles into the record.

[The information referred to follows:]

A CHINESE SPACECRAFT HAS BEEN CHECKING OUT U.S. SATELLITES
HIGH ABOVE EARTH

Andrew Jones—March 3, 2023



An illustration of Earth showing how far away geostationary orbit is.

A Chinese satellite launched in 2018 has been inspecting other nations' spacecraft high above Earth in geostationary orbit.

Tongxin Jishu Shiyan Weixing-3 (TJS-3), named vaguely as a communications experiment *satellite*, was sent up into geostationary orbit in late 2018. It then released a small subsatellite, possibly to help test TJS-3's capabilities.

Orbital data reveals that TJS-3 has been making close approaches to American satellites in recent months. For example, the Twitter account *Orbital Focus* notes that the satellite has been drifting along the geostationary belt, but pausing to take a closer look at satellites USA 233 and USA 298, both thought to be military communications satellites operated by the *U.S. Space Force*.

Satellites in geostationary orbit (GEO) operate at 22,236 miles (35,786 kilometers) above *Earth*, where their velocity matches the rotation of the planet and sees them appear fixed over one point on the surface below. This orbit is thus highly prized for its use for communications and other purposes.

At the same time, a spacecraft that either raises or lowers its orbit a few tens of miles will be able to drift west or east respective to other satellites, allowing a satellite over time to sweep past others and take a look.

Satellite Dashboard, a web tool that collates and analyzes space situational awareness (SSA) data, reveals that TJS-3 *approached* as close as 3.8 miles (6.2 km) to USA 233 on Oct. 31, 2022.

Related stories:

- Chinese scientists call for plan to destroy Elon Musk's Starlink satellites

- 2 Russian satellites are stalking a U.S. spysat in orbit. The Space Force is watching.
- Is Earth-moon space the U.S. military's new high ground?

U.S., Russian and Chinese satellites have all increasingly been *scouting each others' satellites* in GEO in recent years, using close approaches to attain images and other data.

This has led to a game in which countries aim to learn about each others' spacecraft and test their counterspace and SSA capabilities.

Little is known about the TJS-3 satellite, but the U.S. and other nations will doubtless be watching its movements closely.

Chinese politics & policy

CHINA BUILDING CYBER WEAPONS TO HIJACK ENEMY SATELLITES, SAYS U.S. LEAK

Classified CIA document assesses Beijing's ambitions to take control of communications critical to fighting wars



The Dragon SpaceX satellite. China's ambitious cyber attacks aim to mimic the signals that satellites receive from their operators, tricking them into being taken over or to malfunction © European Space Agency

Mehul Srivastava in London, Felicia Schwartz and Demetri Sevastopulo in Washington—APRIL 21 2023

China is building sophisticated cyber weapons to “seize control” of enemy satellites, rendering them useless for data signals or surveillance during wartime, according to a leaked U.S. intelligence report.

The U.S. assesses that *China's* push to develop capabilities to “deny, exploit or hijack” enemy satellites is a core part of its goal to control information, which Beijing considers to be a key “war-fighting domain”.

The CIA-marked document, which was issued this year and has been reviewed by the Financial Times, was one of dozens allegedly shared by a 21-year-old U.S. Air Guardsman in the *most significant American intelligence disclosures* in more than a decade.

A cyber capability of this nature would far exceed anything Russia has deployed in Ukraine, where electronic warfare teams have taken a brute-force approach with little effect.

These attacks, first developed in the 1980s, attempt to drown out signals between low-orbit SpaceX satellites and their on-ground terminals by broadcasting on similar frequencies from truck-borne jamming systems such as the Tirada-2.

China's more ambitious *cyber attacks* aim to mimic the signals that enemy satellites receive from their operators, tricking them into either being taken over completely or malfunctioning during crucial moments in combat.

The classified U.S. document said this cyber capability would allow China “to seize control of a satellite, rendering it ineffective to support communications, weap-

ons, or intelligence, surveillance, and reconnaissance systems". The U.S. has never disclosed whether it has similar capabilities.

Taiwan, which has taken note of how indispensable satellite communications have been to the Ukrainian military, is seeking to build out communications infrastructure that can survive an attack from China.

It is courting investors to establish its own satellite provider, while experimenting with non-geostationary satellite receivers in 700 locations around Taiwan to guarantee bandwidth in the event of war or disasters, *the Financial Times reported in January*.

In a sign of how crucial satellite communications have become in warfare, a Russian cyber attack succeeded in rendering thousands of Ukrainian military routers from US-based Viasat ineffective in the hours before it launched its full-scale invasion on February 24 last year. A Ukrainian official described the attack at the time as "catastrophic".

It also knocked out service to thousands of Viasat customers in Poland, Italy and Germany, where several hundred wind turbines were affected.

The Viasat hack, while sophisticated, involved *breaking into the company's computer systems* and sending out instructions to the modems that caused them to malfunction.

China's goals, according to the leaked assessment, are far more advanced. They would seek to knock out the ability of satellites—which tend to operate in interconnected clusters—to communicate with each other, to relay signals and orders to weapons systems, or to send back visual and intercepted electronic data, according to experts.

US military officials have warned that China has made significant progress in developing military space technology, including in satellite communications.

General B Chance Saltzman, commander of the U.S. Space Force, told Congress last month that Beijing was aggressively pursuing counter-space capabilities in an effort to realise its "space dream" of becoming the foremost power beyond the Earth's atmosphere by 2045.

"China continues to aggressively invest in technology meant to disrupt, degrade and destroy our space capabilities," he said.

Saltzman said China's military had deployed 347 satellites, including 35 launched in the past six months, aimed at monitoring, tracking, targeting and attacking U.S. forces in any future conflict.

Charlie Moore, a retired Air Force general who served as deputy of U.S. cyber command, said China was making huge efforts to counter the asymmetric advantage that the U.S. had in the cyber and space domains.

"China understands the superiority that the United States has in the space and cyber domains, so they are very interested in not only improving their own capabilities but in capitalising on what we refer to as a first-mover advantage in both domains," said Moore, now a visiting professor at Vanderbilt University in Tennessee.

"They are working on all the capabilities that they want to have from a defensive and offensive standpoint, and from an ISR [intelligence, surveillance and reconnaissance] standpoint. They're firing on all cylinders," he said.

The National Security Council, the CIA and the Pentagon declined to comment. The Chinese government had no immediate comment.

Additional reporting from Joe Leahy in Beijing

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The CHAIR. We will now turn to questioning, and, Administrator Nelson, I wrote to you in January about a manufacturing USA Institute, something that NASA could inform, is really an action that NIST would take. But in my State alone, we are looking at 60,000 STEM worker shortfall by 2026, and this notion of continuing our efforts on material science, I believe, is a key aspect of where we need to go.

So NASA, NIST, industry need to continue to collaborate on what I think is training and skilling people in material sciences. Do you agree that NASA should help and work on these issues?

Senator NELSON. Indeed I do, and another thing that you were looking at is thermoplastic composites as a new material that would not only help aviation industry, but also the space industry. And we have a NASA project going on on high-rate composite air-

craft manufacturing, and we are working with the partners, obviously those in Washington State as well, to reduce the cost and increase the production rate of composite aircraft. You know, the Dreamliner, the 787, is built of composites, and it has a lot of advantages, including a weight advantage. And so this is a new kind of composite.

So at your request, Madam Chairman, NASA, Commerce, Defense are developing recommendations to leverage the manufacturing here in America to accelerate our capabilities in manufacturing aerospace technologies, like thermal plastics.

The CHAIR. Thank you. Thank you for that answer. I think there are some that believe we are falling behind to where Europe is on this R&D side of the equation, so thank you for your answer on that. I would like to ask a couple of other things. Obviously, you and I have had many conversations about NASA's need to continue with redundancy and making sure that we keep programs, you know, on schedule and reduce risks, and also the fact that we need a multi-year budget.

The President's 2024 budget for NASA is a 7-percent increase over 2023, but your requested increases in the out year appear to be only 2 percent or less. So we think here in discussions, getting a 3- to 5-year authorization would help NASA on making sure that we do not fall behind in what we need to do to be competitive. Thank you for your detailed answer on thermoplastics. Many of our supply chain are making thermal plastic products today for the space sector, and so we appreciate that answer.

But could you talk a little bit about a multi-year request and how do we stay competitive in redundancy?

Senator NELSON. And I commend you for a multi-year proposal. It is true that the last NASA authorization bill, as Senator Cruz has mentioned, the two of us fashioned that. That was back in 2017. It is true that for that, one of the primary drivers was the NASA bill of 2010, which Kay Bailey Hutchison of Texas and I fashioned, that set us off on this course of the dual approach in our going back to the moon and to Mars. One track is government. The other track is commercial.

And so I would welcome a multi-year approach to appropriations instead of in the past where it has been you get into the negotiation between the House and the Senate, and then you all cannot agree on this, and you have to accept what they want, but that is not the comprehensive approach. I think what you have said, a 5-year authorization bill, would be very, very well received in the aerospace community.

The CHAIR. Thank you. Senator Sinema, I am turning the hearing over to you, and thank you for chairing. Oh my gosh. Totally forgot your opening statement.

Senator NELSON. Well, I was going to shorten it and—

The CHAIR. Totally. I jumped right into questions, and so we had such a dynamic here of members talking about all these priorities. Sorry. I apologize for not giving you the opportunity to make a statement.

Senator NELSON. Well, let me—let me just see, Mr. Chairman, if I could hit some of the topics—

The CHAIR. Please, go right ahead, Administrator. Oh my gosh.

Senator NELSON.—that you four raised in your opening questions.

**STATEMENT OF HON. BILL NELSON, ADMINISTRATOR,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Senator NELSON. First of all, we have talked about aviation, and you are so right, and they are big things happening in aviation. Just for example, in Washington State, we have just announced with Boeing basically the plan to design the next 737 aircraft, which is the one that is most frequently used, single-aisle, medium-range, commercial transport. But this time we are going to do it by working with Boeing of designing a high, thin wing, high on the fuselage, and it is so thin that it needs struts to support it. But what this design is doing is giving, along with the improvement in the engines, a 25-percent greater efficiency. And, Senator Cruz, that would mean 25 percent less fuel, which is a good thing for the airlines, but might also be a good thing in the overall energy policy of the country.

Senator Cruz, you mentioned the GHC. You and I in this committee have a different approach to what is happening to the earth's climate. It so happens that NASA is in the middle of this. Why? Because all those assets up there. We design them, we build them, we launch them, and we operate many of them. Others we turn over to like NOAA, and NOAA then, of course, has the National Weather Service.

Now, the fact is that they are recording what is happening to the earth, and what you are specifically referring to is, in 2022, the Federal Acquisition Regulation Counsel published a draft rulemaking. That is in the draft. There are three agencies involved: NASA, Department of Defense, and I think it is, which one? GSA. And so it is in the middle of taking comments, but there is a provision in there, if this will give you some satisfaction. There is a provision in there that I, as the NASA Administrator, can waive any requirements that might be in the rule with regard to small business, and small business is something that we take very seriously in our contracting and so forth. So I would ask you to continue with your advocacy of that position but look at the details in the proposed rulemaking, and it is in the hearing stage accepting comments.

Senator Sinema, I brought show and tell. You raised this issue. This is DART. This was incredibly successful. We wanted to see if we could hit, bullseye, an asteroid. So we chose an asteroid that was about 100 meters in diameter that was orbiting about another asteroid that was about a half a mile in diameter, because if we hit it, we could then measure with our telescopes did we move it.

This is DART. The size of DART is 4 by 4 by 4, so it is a relatively small spacecraft, but that spacecraft hit that 350-foot wide asteroid at 16,000 miles an hour right on the money, and sure enough, it changed the orbit of that. And, therefore, we wanted to see if we could hit—if we discover a killer asteroid is headed for earth, would we have a chance of altering its trajectory by hitting it, and that brings this one: Arizona State NEO Surveyor. This is a 3D printing of what is the spacecraft. It is obviously much, much larger than this, and it will go in 2027, and it is going to be looking

out there for killer asteroids that would endanger us. So this program, primary principal investigator is Arizona State. I have been there. I have talked to them, and so I wanted to bring you all up to date on that.

And, Senator Schmitt, you raised the issue of China. We are in a space race with China. The staff of this committee has already received an intelligence briefing, and I would encourage you all to get that briefing to understand just how serious this space race is of getting on the moon. And I have said many times that—it is my old country law practice days—possession is nine-tenths of the law. It is always possible that to get to the area that we are going to, the South Pole, where we think the resources are on the moon, especially water, and, of course, if there is water, there is hydrogen and oxygen, and you got a gas station. I would not want us to be there second because what is to say, if you recall the history of China, the Spratly Islands in the South China Sea, and suddenly they are claiming that is their territory. I would not want to see them get there first and then claim this is our territory in the South Pole, you stay out. We go as an international mission. We go with international astronauts. We go with international participants in our scientific instruments. I want us to get there first.

[The prepared statement of Senator Nelson follows:]

PREPARED STATEMENT OF HON. BILL NELSON, ADMINISTRATOR,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Chair Cantwell, Ranking Member Cruz, and members of the Committee, I am pleased to be here to discuss the President's \$27.2 billion request for NASA for Fiscal Year 2024. NASA has set a bold vision for the future, one defined by innovation and exploration throughout the heavens. This request will help prepare NASA to make that vision a reality, through investments in human and robotic exploration throughout our solar system, Earth science, groundbreaking technology, the next generation of air travel, and educating our Nation's future explorers. It's an investment to support good-paying jobs, businesses, and schools that partner with NASA in all 50 states. This request supports almost 150 missions, and I would like to highlight a few for you today.

In November 2022, NASA took the first major step in America's return to the Moon with the Artemis I mission. That historic launch and 25-day mission tested the Space Launch System, Orion spacecraft, and Exploration Ground Systems in preparation for Artemis II in 2024, which will carry humans beyond low-Earth orbit for the first time in more than 50 years. That mission will be followed by Artemis III in 2025, which will return astronauts to the surface of the Moon. The Budget requests more than \$8 billion for the Artemis program, putting the Nation on a path to annual crewed missions to the surface of the Moon starting with Artemis IV in 2028.

Through the Artemis campaign, NASA is partnering with the broadest exploration coalition in history, including multiple international and commercial partners. Together, we will continue to develop the technology and systems needed to live and work on and around the Moon in preparation for human missions to Mars. The Budget makes investments in the long-term architecture for Artemis, including enhancements to the Space Launch System, new ground infrastructure, the Gateway lunar space station, space suits, and competition in the Human Landing System program that will enable the first woman and person of color to walk on the Moon.

The missions of tomorrow will be enabled by the technology development of today. With an investment of nearly \$1.4 billion for space technology, the Budget funds development of communications and power systems needed for long-duration stays on the Moon. Investments in new capabilities like advanced propulsion and landing systems will enable humanity's next giant leap to Mars.

The \$4.5 billion request for Space Operations supports continued research on the International Space Station (ISS) with regular crewed missions to this orbiting laboratory through 2030. There, NASA astronauts conduct research on the risks associated with future deep space exploration missions and perform groundbreaking ex-

periments on human health that benefit life on Earth. Increasingly, the ISS is hosting experiments that look back at Earth to help us observe and understand changes to the planet. The Budget positions NASA to continue the space station's legacy in low-Earth orbit after its planned retirement in 2030, with investment in the development of commercial space stations, while also investing in a U.S. capability to safely deorbit ISS at the end of its life. Collectively, these investments will pave the way for sustained American presence in orbit and create scientific and economic opportunities.

In 2022, NASA had the world on the edge of their seats as we revealed the first images from the James Webb Space Telescope. The \$8.3 billion request for science will continue worldleading missions like Webb, Hubble, and Perseverance, as well as enable the next generation of great science with the Nancy Grace Roman Space Telescope, Mars Sample Return, Europa Clipper, Dragonfly, and more. The FY 2024 Request is the highest request for NASA science in history, supporting over 120 NASA science missions and 10,000 U.S. scientists through more than 4,000 openly competed research awards.

Over the past three decades, much of what we have learned about the Earth system has been built on NASA satellite observations and research. The Budget will build on that legacy by funding the next generation of Earth observatories that will give us a 3D-holistic understanding the Earth's systems. The Budget request will make NASA's Earth Science data more accessible to Federal, state, and local governments, universities, researchers, and the public through the development of the Earth Information Center and other data initiatives. NASA's direct observations, made on and above Earth's surface, put humanity in the best position to measure and respond to changes in our environment while confronting challenges that impact all of humanity. Focusing our efforts on the Earth, planetary defense, orbital debris, and the safety, security, and sustainability of space will equip policymakers with the best information possible to protect our planet.

Through ambitious experimental programs, including the X-57 electric aircraft, X-59 low boom supersonic aircraft, and the Sustainable Flight Demonstrator, NASA is poised to revolutionize the future of air travel and keep U.S. industry competitive in the global marketplace. The Aeronautics budget request of almost \$1 billion will put the U.S. aviation industry on a path to meet the ambitious goal of net zero emissions by 2050. We are accelerating research and development of aircraft technologies that are safer, faster, and more fuel efficient.

NASA has always dared to make the impossible possible. To do so, the \$158 million request for the Office of STEM Engagement will build the workforce of tomorrow by broadening student participation, expanding K-12 student engagement, and building partnerships to magnify our reach.

NASA's success is made possible by our world class workforce and enabled by our physical infrastructure. The Budget request contains investments to ensure NASA infrastructure, laboratories and critical facilities are safe, secure, and mission ready. Robust investment in construction, revitalization, and maintenance of facilities is essential to ensure NASA can meet our mission requirements.

The President's Budget request for NASA is an investment in our Nation's future. It is an investment in U.S. innovation and competitiveness, and it is an investment in our next generation of workers. It will prepare America to compete—and succeed—in the 21st century.

The CHAIR. Thank you—

Senator NELSON. Madam Chairman—

The CHAIR. Thank you for that passionate opening statement, Administrator.

Senator NELSON. I didn't get to the budget, which you asked about.

The CHAIR. We will—we will get to that. I want to turn to my colleague, Senator Cruz, and then we will, again, thank Senator Sinema for chairing the rest of the hearing and for her leadership. She mentioned CHIPS and Science, and that was a key aspect of the CHIPS and Science Act. She played a key role in helping us get it over the goal line, and so appreciate it and appreciate your focus this morning. So, Senator Cruz.

Senator CRUZ. Thank you, Madam Chair, and as I said, it is—it is good, Administrator Nelson, to have you back in the Committee. It is unusual to have you on that side of the dais.

Senator NELSON. And by the way, thank you for coming to Houston for the announcement of the crew. This is a big deal, and, by the way, the crew is here today—

Senator CRUZ. Good.

Senator NELSON.—and tomorrow and Thursday. And it is my understanding that I am going to be able to bring them to the Republican luncheon on Wednesday, and so I look forward to you seeing them there.

Senator CRUZ. Excellent, and they are so incredibly impressive, and we are proud of the courage that they bring in this incredibly important mission, going back to the moon, but also keeping our eyes focused that Mars is the objective, and getting to the Moon as an integral part of proving up the technology to go to Mars.

I want to start by asking about, NASA has a long history of phasing down programs. And we saw with the space shuttle, with Constellation, that there can be real bumps in a phase-down. At some point, the International Space Station is going to need a phase-down. We have extended the time on that until at least 2030, but at some point, that is going to have to happen. How do we avoid a brain drain, and how do we maintain the technical expertise and leadership we need when that time comes?

Senator NELSON. First of all, understand that among young people, which we actively recruit in our intern program, the excitement about space—I often say, “space is the place,” but that is not some light statement. Look at any classroom in America, and look at the excitement in the areas of engineering, and mathematics, and technology, and science, and it is real. And what better way to get the young people of the country motivated than the Space Program? It was that way 50 years ago in Apollo, and we are reviving that now again with Artemis.

So I think as then, specifically to your question, how do we keep this going, in large part, it is going to depend on you all and the challenges that you all have in the next couple of weeks, and then the challenges as you get up to September the 30th on the appropriation deadline for the next Fiscal Year, Fiscal Year 2024. But if the resources are there for us, then we are going to have this continuing program of going back to the moon, this time to learn, to live, to work, to invent, to create for the purpose of going further, going to Mars. That is going to generate a lot of excitement.

When you combine that with all the science that is going on—I just mentioned DART and NEO Surveyor, the James Webb Space Telescope, and the discoveries that it is bringing, you mix all of that together, and there is going to be a continuing interest.

Senator CRUZ. You just rightly noted that—one of the challenges of ensuring NASA’s exploration focus are the constraints of resources, and that has always been the case. It is worth noting that NASA’s acquisition management has been on GAO’s High Risk List for years, and GAO noted last year that “Continuing their recent trend, NASA’s portfolio of major projects experience significant cost and schedule overruns, and more projects were added.”

That is one of the reasons why I and every Republican member of this committee is so concerned about the proposed new greenhouse gas rule. It is estimated that rule will increase costs among Federal agencies across the board by almost \$4 billion, a significant portion of which will likely be borne by NASA. Has NASA done any calculations? Have you measured how much this new proposed rule will drive up the cost for all the companies that do business with NASA and, in turn, how much more that will drive up NASA's expenses and remove dollars that otherwise would be available to go to the moon or to go to Mars?

Senator NELSON. In the process of the rulemaking, they are receiving comments, and then I will be able to answer your question specifically. But we cannot deny that NASA deals with climate, and, therefore, it deals with these greenhouse gases. That is what we have the instruments up there taking these measurements.

Senator CRUZ. But, Administrator Nelson, my question is just how much are you all driving up costs because of a political mandate from the White House? I will give you another example.

Senator NELSON. I will get you an answer.

Senator CRUZ. One of the "works in progress" under "safety, security, and mission services" within the budget is to implement a 5-year plan to transition NASA's entire fleet of more than 2,600 traditional combustion vehicles to all-electric vehicles. Has NASA done any cost estimate as to how much it will cost to get rid of 2,600 combustion vehicles, replace them with electric vehicles, and then install the charging infrastructure everywhere that will be needed for those vehicles?

Senator NELSON. I will get you an answer, but if you are suggesting that we should abandon the entire national effort to move toward electric vehicles, I would say that there is a significant difference of opinion about that.

Senator CRUZ. What I am suggesting is NASA should stay focused on its core mission of going to space, and going to the moon, and going to Mars. And the extent to which—I understand this is a very political White House. I understand most White Houses are. The extent to which NASA salutes and jumps on board with those political objectives, that will significantly undermine not only the ability of NASA to have the resources it needs to keep building things to go to space, but it also—we have worked very hard—you and I have worked very hard to keep NASA out of partisan politics, and I would encourage you energetically to continue that work because we have got a Republican House of Representatives now. If NASA is seen as partisan, that is very bad for space and space exploration, and so I hope NASA will continue its tradition of staying out of those battles.

Senator NELSON. And I assure you NASA is and will be if, I am around, not only bipartisan, but nonpartisan, and it will continue that way. Now, the reality is, Senator Cruz, and you know I love you, it is the fact that we have political differences, and it was on display in this very room over a number of years. But I can guarantee you that NASA is being run in a nonpartisan way.

Senator SINEMA. Thank you. Welcome again, Administrator Nelson. I will now recognize myself for a few round—a few questions.

I am proud of Arizona's longstanding leadership in planetary defense, including addressing the threats of destructive near-earth objects, or NEOs, as you have discussed. In fact, the Catalina Sky Survey and Space Watch at Kitt Peak in Arizona have detected more than half of all of the identified NEOs. Unfortunately, to date, NASA has only identified approximately 42 percent of the NEOs larger than 140 meters in size that could cause a devastating impact should they hit the earth. This is far less than the 90 percent by 2020 that was required by the 2005 George E. Brown Junior Near-Earth Object Survey Aircraft.

However, the NEO Surveyor Mission led by Professor Amy Mainzer at the University of Arizona, would dramatically increase the rate of discovery of NEOs through a space-based infrared telescope optimized to find, track, and characterize the NEOs. Now I have strongly supported funding for this mission in the past, and I want to ensure that it is adequately funded to fly before the March 2028 deadline. So why is this year's \$209.7 million budget request for the NEO Surveyor Mission, as well as continued support for additional funding in the future years, so essential to meet the statutory requirements and protect our planet from potentially harmful objects?

Senator NELSON. We cannot identify every object. However, NEO Surveyor will be able to identify 90 percent of all the potential asteroids that are greater than 140 meters wide within the 10 years of the launch. Now, that is important because when you think of an asteroid that will do serious damage—millions of years ago, the asteroid that wiped out the dinosaurs was about 6 miles wide. If we can identify 90 percent of the asteroids that are 140 meters wide, then we are well on our way, but that is the technology that this will enable us to do, and launching it in 2027.

By the way, there is a similar problem. Look at all the junk in earth orbit. There are a lot of pieces up there that are big, and they can do damage coming down through the atmosphere because they do not all burn up. We can only identify with existing technologies pieces that are larger than that in width. But something like that coming back to the atmosphere can still do a lot of damage.

Senator SINEMA. Thank you. Is NASA on track to meet the March 2028 launch readiness date required by the CHIPS and Science Act?

Senator NELSON. Are we talking about silicon chips? Is that what the question is?

Senator SINEMA. So the CHIPS and Science Act required that NASA meet a launch readiness date. This was part of the reauthorization package that was inside CHIPS and Science, and the idea was that you would be ready to launch by March 2028.

Senator NELSON. Which mission are we asking?

Senator SINEMA. The Surveyor. The NEO Surveyor.

Senator NELSON. Is it not going in 2027? 2028.

Senator SINEMA. We are on track?

Senator NELSON. We are on track.

Senator SINEMA. Great. Thank you. Arizonans face tremendous challenges from urban heat, water availability, and wildfires, and as you know, the CHIPS and Science Act directs NASA to pursue earth system observatory missions. So how will you ensure that

these missions advance the critical science that will allow Arizonans to better plan, avoid, and mitigate these challenges?

Senator NELSON. Well, the specific question is about—would you state that again?

Senator SINEMA. Sure. Thank you. So how will you ensure that NASA's missions around earth system observatory missions actually advance the critical science that allows Arizonans to better plan for issues like urban heat, wildfires, and water?

Senator NELSON. OK. There are four great observatories that we are going to put up over the course of the next decade that will do what you just described, the Earth System Observatory. As a result of these, and, by the way, this is part of the science budget that I would urge you all to continue on. As a result of these, we are going to have a 3D compendium of everything that is happening to the earth in its land, in its water, in its atmosphere, and its ice, and how that is affecting everything on earth.

For example, I had gone to Kansas for Senator Moran, and one of the reasons I wanted to go is that we have systems up there, including Landsat, but so much so with this Earth System Observatory, that the chairman has just mentioned, that can tell a farmer in his particular pasture crop, that particular segment of land, what is the moisture content of the soil. And as a result, it has the applications here on earth, all the more so when we put up these four great observatories giving us an understanding of what is happening to the earth, so much greater.

I would just add one other example, and that is we can tell, for example disease in crops, but also disease in trees. And so we can warn that there is likely to be a wildfire in a particular forest as a result of the vegetation that we are detecting from space as being diseased.

Senator SINEMA. Thank you. Senator Schmitt.

Senator SCHMITT. Thank you, Madam Chair, and it is good to see you again. We had a great visit in my office, and I noticed you already pulled out the "I am just a country lawyer" line earlier, which is one of my favorites.

[Laughter.]

Senator SCHMITT. But anyway, it is good to see you again.

I did want to ask you, you know, NASA has such a great tradition and reputation as relates to working with private industry for the development of new technologies, and you see this kind of innovation, and it is only continuing to grow. And we are on this—I mean, space has always been referred to as the final frontier, but we are continuing to push that envelope, which is—which is great. Could you give the Committee, or the three of us, I suppose, an idea of what you are doing or some specific efforts that you have employed as commissioner or the Agency in general to help foster that kind of innovation as opposed to being an impediment, because this is one of the—you know, obviously, the great concerns is government getting too involved, potentially stymieing some of that innovation, and this is—you know, with space.

I appreciate your comment earlier about China. I serve on the Armed Services Committee as well, and, you know, China is playing for keeps, and space is, you know, sort of ground zero for that competition that we are in. So just if you could walk through some

of the things that you are doing that help foster innovation as opposed to hinder it.

Senator NELSON. Our seed corn is research and development. We do not want to ever give that up, and that is the mission of NASA. It may be in space. It may be aeronautics. It may be in climate by what I just described. It may be looking for asteroids. It may be trying to understand these phenomenon that you are being briefed on in the Senate Armed Services Committee on UAPs. It has got a new name: unidentified anomalous phenomena.

Senator SCHMITT. Mm-hmm.

Senator NELSON. It may be all of this, but it is the research and development that allows this country to move forward, so we see it in so many things. The reason it is going to accelerate and sustain itself is we do it not just as a government agency, but we do it with our commercial partners and now our international partners, and that all brings to the table a new mix of research and development, whether we are talking about space.

Let's take the example there, our going back to the moon. Now we go and have already demonstrated, without a crew on the test flight, the Artemis Mission Number I, and the spacecraft, Orion, flying around the moon, we are putting a crew on. But we go with commercial partners because the third mission, we are going into lunar orbit. We are going to start to establish a lunar space station, and we are joining up with a commercial lander. The first winner of the first competition was SpaceX. We have a second competition that is just coming to a close, and the winner of that competition, so we—will be announced very shortly, and so we will have two landers. And, therefore, it is a public/private partnership.

We also—to go back to the moon this time in a different way, we go with our international partners. That was not the case half a century ago. We did it as the U.S. Government. This time, even on the first crew, the ones that are coming here to Capitol Hill today, our first international astronaut is Jeremy Hansen, a Canadian F-18 Royal Air Force pilot. And so it is the beginning of these international crews. Now, on the International Space Station, we have been having international crews there ever since the late 1990s when we opened up the International Space Station.

Senator SCHMITT. Well, I appreciate that, and I am limited on time, but I do want to make the point in following up with some of the comments from Senator Cruz. And he was talking about climate, and you have indicated that China is a—is a serious threat competitor here. In the budget, it is worth noting that China is mentioned one time in the budget.

[Cellphone ringing.]

Senator SCHMITT. "Les Miserables." I hear the ringtone.

China is mentioned one time, but climate and DEI-related items were mentioned 153 times in the budget. Talk about priorities, not that that is the litmus test, but my concern is in also serving on Armed Services Committee, we have had leadership of Senator Wicker as the ranking member, had a lot of questions to some political appointees to those positions about, again, this obsession with this political ideology. And NASA has had such a great reputation, I do not want to see NASA dragged into these political

fighters and the politicization that dominates everything. NASA has no business in that.

So it is more of a comment than a question. I would urge you to rethink this—again, this administration’s obsession with this divisive ideology that is now finding its way in military budgets, NASA budgets, and I just think it is completely wrongheaded, but thank you for your time today.

Senator NELSON. Thank you, Senator.

Senator SINEMA. Senator Wicker.

**STATEMENT OF HON. ROGER WICKER,
U.S. SENATOR FROM MISSISSIPPI**

Senator WICKER. Well, thank you very much, and it is great to see you again, Mr. Administrator, and I congratulate you on the great work you are doing. It may come as a total shock to you that I would want to ask about the Stennis Space Center. But you and I have worked on this world-class facility in the past, and I understand you have some words of encouragement about Stennis and other space centers as we transition to a different phase of NASA’s long and very vital career. So what could you tell us on the record about that?

Senator NELSON. The Stennis Space Center is a very valuable national asset because it is the location that, when we are developing exquisite new engines, we have to go to test them. And it is strategically located so that huge rockets can be delivered there on barges on the canals that once tested, and their motors in the integrated form can be put back on the barges and sent to the launch site wherever the launch site is.

Now, the testing of rocket engines is not going to cease. It is going to continue, but they are new kind of rocket engines, so it is not just government rocket engines. It is now commercial rocket engines because, indeed, there is a very viable commercial space industry now, not only satellites but also rockets that are finding cheaper ways to get up to orbit because of exquisite new materials and manufacturing techniques.

So I see a very bright future for the Stennis Space Center, and that future, I think, includes, because Stennis has so many thousands and thousands of acres of land so that its testing does not disturb the surrounding community, I think it becomes a multi-user space center—test center that will be utilized by many other users other than the U.S. Government. But beyond NASA, I think in the U.S. Government, there are many other users in the U.S. Government that will test in the future and, in fact, are beginning to test at Stennis.

Senator WICKER. OK. Well, let me then transition to another aspect of this, and that is the budget for rocket propulsion testing. It has held steady. I would have preferred and been more reassured if that had been increased over time as only a 0.8 percent proposed increase from Fiscal Year 2023 to Fiscal Year 2024. Where do you see that going, and giving the—given the unfunded infrastructure projects in our rocket propulsion test centers, is this funding request going to be sufficient to sustain the programs?

Senator NELSON. I want to see it increase and, thus, all the more reason that you all need to keep us out of budgetary chaos. And

I am not talking about in the next few weeks. I am talking about also when we get close to September the 30 and we need a new appropriations bill. So your question specifically is, are we going to have increased need of increased appropriations in order to provide the testing facilities for our space rocket, and the answer, in large part, is up to you.

By the way, we have \$5 billion of unmet needs on infrastructure. Fortunately, we were able to address some of it in an emergency appropriations for both Michoud and New Orleans as well as Stennis because of hurricanes. So in a hurricane supplemental, we were able to repair damage, but this is throughout all NASA's 10 senator—10 centers and 10 facilities. We are sucking air when it comes to the needs of infrastructure.

Senator WICKER. OK. Well, I appreciate your answer, and, Madam Chair, I will yield back in a sentence or two. But I think what I hear you say is that, yes, we could and, in fact, need some additional appropriation in order for these testing facilities to meet the needs that we have. I certainly agree with you when you talk about continuing resolutions and the way they do not meet the needs and, in fact, waste—waste—billions and billions of dollars when we are forced to continue under last year's plan rather than move forward on what is actually needed. So I appreciate you working with us on this, and, of course, you do not have a stronger supporter of the Artemis Program and the space programs than many of the members on this side of the dais. Thank you, Madam Chair.

Senator SINEMA. Thank you. Senator Hickenlooper.

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

Senator HICKENLOOPER. Yes, and thank you, Mr. Nelson. We have got some sort of a space object between us.

You have referred a little bit to some of the risks and dangers of debris. The Orbits Act, which passed the Senate unanimously in the 117th Congress, would jumpstart a partnership with industry to figure out how we are going to develop the technologies to get this debris out of the LEO. I think it is—it is critical for tackling this problem that continues to grow.

Now, other nations, including European nations, the Japanese space agencies have all established dedicated programs to advance their own debris removal technologies. Can you describe NASA's current efforts to address orbital debris and what you could call the orbital debris crisis, and how does NASA plan to maintain its global leadership in active debris removal?

Senator NELSON. It is a real problem, and we are going to have some catastrophic consequences if we cannot get nations that are launching things into space to provide enough fuel to have a controlled reentry and, in fact, to have a reentry so that all the junk is not sitting up there. One of the obvious examples is the ASAT test that was done by China a decade ago put tens of thousands of pieces right in that zone of altitude of where a lot of our spacecraft are and, indeed, our International Space Station.

Most recently, Russia as well about a year ago did an ASAT test, unbelievably putting junk into the very altitude where the Inter-

national Space Station is, which they built with us and operate with us with their cosmonauts on board. And, in fact, we have had to move the space station to a higher elevation to get out of the way of junk that we can identify.

And earlier in the hearing, I was saying that we can identify in low earth orbit objects that are that long or greater, but smaller stuff, we cannot even identify yet, and it is a real threat. I mean a speck of a paint chip coming at the right velocity at the right angle, you can imagine what it could do to a space suit on a spacewalk of an asteroid.

So there has got to be not only our effort, and it looks like we have to lead the international effort, to be serious about designing everything that we are launching, that it has a minimal amount, preferably none, amount of junk that is going to be up in space, either to let it degrade and burn up on reentry, or to get it into a higher graveyard orbit—

Senator HICKENLOOPER. Right.

Senator NELSON.—where it is not going to threaten anything.

Senator HICKENLOOPER. Great. I appreciate that. We are working on it as well to try and provide you the resources for—to make sure that technology does get developed in this country. Going to let you free range a little bit just with the last question, which you only have about 40 seconds. We have a whole bunch—over 200 Colorado companies have played a role in the successful Artemis I mission, supporting the development of a space launch system and the Orion spacecraft. The CAPSTONE satellite is owned and operated actually by a Colorado company, Advanced Space. I think they are still orbiting the moon as we speak sending back critical information for the Artemis mission. So just giving you an open palette, can you describe the value of the public/private partnership in our return to the moon? How is NASA engaging our industry partners to keep the human landing systems and the Lunar Gateway on budget and on schedule? And you are only going to have about—maybe you will get 5 extra seconds.

Senator NELSON. Well, I—

Senator HICKENLOOPER. You might have to—you might have to—actually, I should rephrase that. You might have to respond to that in a written since—now that I see that the—

Senator NELSON. Well, I cannot say it in 5 seconds, but I can say that that mission that you are referring to, it is characterizing the orbit that eventually our Gateway or space station will go in.

Senator HICKENLOOPER. Right.

Senator NELSON. It is a California—it is a Colorado company that, in fact, did manufacture the spacecraft, and what is illustrative, it was launched by a private rocket company that, albeit an American company, also it was launched from a foreign location, in this case, New Zealand. Rocket Lab is the company. And it is providing exactly information that we need that the government did not have to do it, but we need that information about this new orbit that we are going to put our Gateway Space Station in lunar orbit.

Senator HICKENLOOPER. Yes, that is great. We are big fans. I yield back. Thank you.

Senator SINEMA. Senator Budd.

**STATEMENT OF HON. TED BUDD,
U.S. SENATOR FROM NORTH CAROLINA**

Senator BUDD. Thank you, Chairwoman. Administrator, thank you for being here today. It is an honor to meet you. Thank you for your service. You know, this committee, as you know, is working through the FAA reauthorization. One area that I hope gets a lot of attention is next-generation aviation technologies. You know, in your testimony, I believe you mentioned the X-59 Low-Boom Supersonic Aircraft Program under NASA's aeronautics research arm. So that flight program could help unlock next-generation commercial supersonic flight through reduced noise pollution.

For example, in Greensboro, North Carolina, North Carolina being the great state that I get to represent, boom supersonic plans to manufacture a commercial supersonic airliner that will revolutionize travel. So what is the current status of the X-59 Low-Boom Program, and, specifically, how close is NASA to meeting its goals on designing and building the research aircraft and flying it over the U.S.?

Senator NELSON. And your state is first in flight.

Senator BUDD. Thank you for that.

Senator NELSON. The X-59, which is this extraordinarily super designed needle-nosed aircraft is going to fly at the end of this year. It will fly out of Edwards Air Force Base. Let us see. It is coming out of the Skunk Works at Palmdale, but I am pretty sure it is going to fly at Edwards, and what it will do is what you just said. It will fly supersonic but its design is such a radical design, that instead of pushing the bow wave going through the atmosphere, as you go from subsonic to supersonic, which causes that audible sound that goes "boom, boom," it will, because of the design as you go supersonic, it will be a muffled roar.

Senator BUDD. Mm-hmm.

Senator NELSON. And the whole thing is just what you said, designed to allow us to travel supersonic over populated areas. An obvious one would be from coast to coast. Now, back in the old days when they had the French Concorde, which was Mach 2, two times the speed of sound, they didn't fly supersonic over the ocean, but when they got to the shores of either Europe or any other location, they had to slow down subsonic because of that "boom" being such a shattering sound.

Senator BUDD. So you hope to fly by the end of the year out of Edwards or Palmdale, but what data do you hope to collect, and how could a successful demonstration clear the way for aircraft manufacturers, like Boom in North Carolina, hopefully not just first in flight in our state, but first in supersonics, how could that help them to have regulatory certainty that there is going to be a market for overland supersonic flight?

Senator NELSON. Well, as a matter of fact, specifically on that question, there are, in fact, private companies that are getting into the business now of supersonic transports, but they do not have this characteristic. So your question essentially is, is there a market out there in going into the headwinds from coast to coast that would normally take you 5, 6 hours? Is there a market out there to cut that almost in half? And I suspect there is, and if you can do that—

Now, you asked also about the testing. This thing is first going to be tested to make sure it flies, and then once they get through that, what we are going to do is a multi-year test, taking it to different locations all over the United States, and see if the muffled roar is acceptable to the people on the ground.

Senator BUDD. So, Administrator, that is the data you are looking for to see if it is acceptable to the public for overland flight?

Senator NELSON. That is correct.

Senator BUDD. Thank you. Chairwoman, I yield back.

Senator SINEMA. Senator Luján.

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

Senator LUJÁN. Thank you, Madam Chair, and, Administrator Nelson, thank you so much for being with us today and for your continued service.

Over the past several decades, Congress has created several agency-modified, nonprofit research foundations. Some of those examples, Administrator, are the National Fish and Wildlife Foundation, the Food and Agriculture Research Foundation, as well and most recently the Department of Energy foundation for Energy Research and Innovation. I believe that a foundation at NASA might help attract more partnerships, more public/private ventures and investments. And so my question, Administrator, is with an appropriate mission and funding, do you believe that NASA could benefit from a foundation to help develop public/private research partnerships, and would NASA be able to use a foundation to enrich public education on space and provide awareness of its role?

Senator NELSON. I do not know the answer to the question. I do know that, Senator, we do everything that we can to partner with not only commercial industry but also universities and other academic institutions. And it has been enormously successful, and the proof is in the pudding. You look at, for example, commercial crew to the International Space Station. That has cost NASA significantly less. Our partner, in this case, SpaceX soon to come Boeing with their Starliner, which should fly later on in the year for the first time with crew, it is on a fixed-price contract, and it delivers crew and cargo to the International Space Station. That was an employment of commercial activities, ingenuity, creativity in a way that NASA had never done, doing it all as a government program in the past.

So, too, in our science research, we join up with commercial ventures as well as academic institutions. We put out a lot of grants, and we specifically, by the way, considering your state, we put those grants into areas that do not normally identify with the aerospace communities because we want the creativity of, in one example, rural communities, that creativity to be brought forth in the scientific research.

So I think we have got the approach of a public/private, for that matter, international partnerships now that we are getting the biggest bang for the buck.

Senator LUJÁN. I appreciate that response, sir. You are familiar with the NASA White Sands Test Facility out in New Mexico, Administrator, which was established back in 1962. It is 94 square

miles located on the western slopes of the San Andreas Mountains, which is 18 miles north of our largest city in the area Las Cruces, New Mexico, and has supported the testing of space flight equipment for decades. Unfortunately, we know that site operations resulted in the release of hazardous substances, including volatile organic compounds from tanks and impoundments used to store waste materials.

NASA is currently stabilizing the contaminant plumes so that it does not grow any bigger, but NASA's own modeling shows this method is not effective at removing all of the contaminants. Even after running the system for 100 years, model simulations show that contaminants are still present. Does NASA believe that it has a responsibility to fully remove the contaminants from the groundwater?

Senator NELSON. Yes, sir.

Senator LUJÁN. And, Administrator, can we expect NASA to identify additional restoration actions?

Senator NELSON. As a matter of fact, we have already spent \$200 million to date to address this groundwater contamination problem, and we are committed to continuing the investigation and evaluation, along with our partner, the New Mexico Environment Department.

Senator LUJÁN. I appreciate that, sir. Administrator, I would like to follow up with your—you and your team on this particular issue. It does matter to us, and there has been a communication from myself and United States Senator Heinrich in the past, going back to 2022, to the Deputy Assistant Secretary of the Army asking about their role and responsibility. And at the time, the response that came back to us said that it was too early to assess damages. It has been about—you know, we are going to be coming up on a year here soon, but just want to make sure that we are on the same page, so I look forward to following up with you, sir.

Senator NELSON. We are on the same page, and NASA owns and operates that local public water system, so we have every reason to continue this investigation.

Senator LUJÁN. I appreciate that, sir. Thank you, Madam Chair.

Senator SINEMA. Thank you, Senator Luján. Administrator Nelson, we have a few Senators who are on their way back. In the meantime, I am going to ask a few questions while we wait for them to arrive.

The last time I was asking questions, I was asking about the CHIPS and Science Act as it relates to Arizona's unique climate issues, such as water, and heat—urban heat, so I want to kind of pick up on that. My question for you now is how will NASA ensure that all the data that is gathered through the Earth System Observatory, how can we ensure that it is available to all states, and tribes, researchers, et cetera, in a timely manner so that, in Arizona, we can address issues like urban heat and water availability?

As you recall, the CHIPS and Science Act requires that that data be provided. Does NASA have a plan to do so in a timely manner?

Senator NELSON. Yes, ma'am, and let me give you a specific answer to your question. Knowing that we have this great observatory that is being put up with four additional elements in addition to what we already have, and the specificity of information of what

is happening to the earth and its climate that will result therefrom, yours truly said we have got to get this information out to everybody. And I knew the concept of a mission control center where everything is on display, so I said why can't we do this for all the information that we are bringing in from all of these assets that are up in space.

What has come to be is our request that was funded the first time last year, we are asking for that funding this coming year, the Earth Information Center. And I see that not just as a physical location in many different locations where people could go, but I see that being offered virtually to everybody—school children, international partners, everybody. We are going to get a first glimpse of this because we have taken the east lobby of our building, which is a stone's throw from here, about 4 or 5 blocks away, and we are remaking that lobby into a very preliminary example of what an earth information center would offer, complete with a board that is constantly bringing information. That is going to be open in about 3 or 4 weeks, and so I want you to come and see it.

And it is just an example of something to come, and that something to come it is going to be extensive information available at the touch of a click.

Senator SINEMA. Thank you. Arizona's major role in space extends to the private sector, and I am proud of the diversity of space companies in my state and everything that they are doing and accomplishing for the Nation. We have a robust business climate in Arizona and look forward to our commercial space partners' continued success. How does NASA plan to invest in the commercial space industry through large programs, like Moon to Mars or Artemis, that will drive innovation and competition?

Senator NELSON. Everything that we are doing is being approached in this commercial public/private partnership. So if it is the example that Senator Luján was talking about of going to the moon, we have a public/private partnership. The government is going to get there with Artemis, with the capsule, Orion, but then a commercial lander is going to rendezvous and dock, and the lander is going to take the crew to the surface. We see that in science. We see the commercial partnerships that are being done.

Another example is the Senator from Colorado, Senator Hickenlooper, was talking about this Colorado private startup company. They have got an instrument in this new orbit that we are going into at the moon that is polar, it is elliptical, and we have never been in that kind of orbit. We are doing it because we are going to have constant ability to communicate with our spacecraft at the moon because it is not going behind the back side of the moon where we lose radio contact. A California startup instrument put up by a private rocket company is what has that instrument in that unusual orbit called the NHRO Orbit.

Senator SINEMA. Thank you. Senator Rosen.

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

Senator ROSEN. Well, thank you, Madam Chair. I appreciate you calling on me, and, of course, Administrator Nelson. Senator Nelson, it is so good to see you here today and hear all the great

things that you are working on. I want to talk a little bit about some things going on in Nevada because we have an area called Railroad Valley, which NASA has been asking for a land withdrawal on that.

So last month, the Bureau of Land Management has approved NASA's application for the withdrawal of over 22,000 acres of public land in Railroad Valley. This area is located in Nye County. It is being used by NASA for calibrating satellites. My team has been told that this site is the only one of its kind in the United States and benefits critical research and national security initiatives.

However, this area in Nevada is also rich with lithium and other critical minerals, and a number of clean energy companies are also looking to pursue projects there. These projects could help provide our domestic supply chain with critical minerals and further our clean energy goals. So I am, therefore, disappointed that up until now and the withdrawal announcement just last month, my office, Nye County, and other stakeholders have had a very difficult time learning about NASA's land request and getting in touch with your Agency. You know, over 80 percent of Nevada's land is Federal, so communication for us is key in ensuring responsible multiple-use land management.

And so can you—will you commit to improving NASA's communication about this effort with my office, Nye County, and other stakeholders as we look at the Railroad Valley land withdrawal and see what the impact is, and really work with Bureau of Land Management with the entities that are interested in developing there as well?

Senator NELSON. Let me define the problem and give you the background. What does this area do? It is flat, and it has a reflective value because of the composition of the soil, that there are only three places in the world that have this: Nevada, China, and Libya, three others outside of the United States, including Israel. Israel, China, Libya, and this site, of which we calibrate our satellites by being able to beam to the earth and those beams come back in order for the satellite to be doing whatever it does. That includes the DOD and the NRO; in other words, the defense and the intelligence missions. Now, from a matter of national security and certainly for the operation of civilian satellites that we operate, we think this is of such an importance, that the United States would not have this access if we were to rely on trying to go to China to do this, or Libya, or, for that matter, our ally, Israel. And as a result, it is essential from a standpoint of national security.

Now, your mining companies think that there is lithium there, and that ought to be explored, but not at the expense of our national security. And indeed, we have talked to your staff, certainly this committee staff, about this issue. Back last year, Senator Cortez Masto called me, and we talked at length about this very project. And to your question—am I committed to continue talking to you—yes, ma'am, I certainly am, and maybe I ought to come out there to Nevada and the two of us go take a look at this, and I would be happy to do that.

Senator ROSEN. Yes. We welcome you coming to Nevada. Like I said, over 80 percent of our land is owned or managed by—it is all public land, and so many different agencies have access to that. In

the meantime, we also have to live with all of that and try to be sure that we are doing the right thing for national security and safety and for our folks in Nevada who live there. So I welcome your visit and to continue this conversation on this and other issues with aeronautical research, and the EPSCoR, and other things in STEM as well. So we will continue the conversation. Thank you so much.

Senator NELSON. Thank you, Senator.

Senator SINEMA. Senator Blackburn.

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

Senator BLACKBURN. Thank you, Madam Chairman. Administrator Nelson, we are always happy to see you and appreciate that you are there today. I do have a couple of questions for you.

Oakridge National Labs. As you are well aware, they are leading the charge on R&D when it comes to new materials, fuels, petrol solutions that are necessary for the Nuclear Thermal Propulsion Program and the success of that program. So what I would like to hear from you, as NASA and DARPA move forward with this inter-agency agreement, how will these two agencies continue to work through R&D that is critical to this program? How are they going to leverage the National Labs and continue to work with them so there is a continuum and a process for this research? And are they going to leverage that research from our National Labs to be certain that we meet those programmatic goals?

Senator NELSON. Senator, this research is absolutely critical for us exploring the heavens. Under conventional technology, chemical propulsion, it would take us 6, 8, depending on the alignment of the planets, 10 months to get to Mars. We just simply cannot sustain a crew for that long, get to Mars, and then have to stay on the surface of Mars for a year or 2 years until the planets realigned in order for us to get back to earth in the same amount of time. And so we got to go faster.

Nuclear thermal and nuclear electric are the two propulsions that can get us there a lot faster. May I say that for the first time, last year, we were able to get in the President's budget, albeit the Congress has been authorizing nuclear thermal research money, but we got everybody on the same page now, all asking for these technologies to be developed.

Nuclear thermal, as you just pointed out, is the first one out of the gate, and it is a joint project between DARPA and NASA. By the way, this is low-enriched uranium. This is not weapons-grade uranium, and the heat that comes from that enriched/low-ridge enriched goes into making nuclear thermal propulsion or the other one, nuclear electric.

It is my hope that we are going to get a joint project with other agencies that will start working on nuclear electric, but they are in Tennessee. You are involved with nuclear thermal, and that is underway as we speak.

Senator BLACKBURN. Well, and I think we all look at this, and we know for a space force to be successful, we have to pick up the pace in this. I want to ask you also about the unmanned aircraft systems because your reauthorization last year gave you the oppor-

tunity to work in this space. And as you are doing some research work on the UAS, I would love to hear from you. We know the Chinese are very aggressive in this. Are you working with any Chinese drone manufacturers or not? What is your participation? Is there private sector participation with you in this program?

Senator NELSON. Yes, ma'am. We are seeing in front of our eyes the change of air transport and mobility as a result of drones. Not only are we seeing the commercial use of these drones, but we are going to see the transport of humans, particularly in the urban setting. So if you want to go from downtown Washington to Dulles and you do not want to fight all the traffic, you will be able to get on a human-rated drone that will lift off electric propulsion and will take you out to Dulles. This will remake transportation in the urban setting and even short—

Senator BLACKBURN. And are you working with any Chinese manufacturers or any Chinese-based research in these programs?

Senator NELSON. Not to my knowledge. As a matter of fact, the—

Senator BLACKBURN. Will you look further into that and confirm to us either yes or no?

Senator NELSON. Of course.

Senator BLACKBURN. Awesome.

Senator NELSON. But let me say that we are well down the road working with American companies on this air mobility.

Senator BLACKBURN. Excellent. Thank you so much. Thanks, Madam Chairman. I yield back.

Senator SINEMA. Thank you, Senator. Administrator Nelson, thank you so much for your participation today.

The hearing record will remain open for 4 weeks, until June 13 of 2023. Any Senators that would like to submit questions for the record should do so 2 weeks from now, by May 30 of 2023. We ask that responses be returned to the Committee by June 13, 2023.

And with that, our hearing is concluded.

[Whereupon, the Committee was adjourned.]

A P P E N D I X

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. MARIA CANTWELL TO
HON. BILL NELSON

Space Technology Development Funding

The Space Technology Mission Directorate (STMD) is critical to the Artemis program and more broadly, to the commercial space industry. In partnership, STMD and commercial industry are developing the technologies we need to establish a sustainable lunar presence and develop a truly commercial economy in Low Earth orbit (LEO).

Innovative technologies and space capabilities create jobs and opportunity in my state and across the country. For example, Ultra Safe Nuclear Corporation in Seattle received funding from the Space Technology Mission Directorate to develop advanced nuclear power and propulsion systems to propel humans to Mars and provide power to our astronauts on the Moon.

Innovative technologies and space capabilities create jobs and opportunity in my state and across the country. For example, Ultra Safe Nuclear Corporation in Seattle received funding from the Space Technology Mission Directorate to develop advanced nuclear power and propulsion systems to propel humans to Mars and provide power to our astronauts on the Moon. The Directorate also funds space flight opportunities for industry start-ups such as Starfish Space in Kent, and Gravitics in Marysville to demonstrate important capabilities in orbit such as cleaning up dangerous space debris and maintaining privately operated facilities for in-space assembly and manufacturing (ISAM).

Question 1. The STMD budget has been relatively flat in recent years and last year's appropriation provided over \$200 million less than the President's Budget Request. This year's request restores most, but not all of the \$200 million gap. Can you describe the impact of not fully funding STMD at the FY 24 request level on critical technology development activities and partnerships with industry?

Answer. Not funding STMD at the FY 2024 budget request would negatively impact the development of crosscutting technologies that enhance capabilities and reduce the cost of space missions. For example:

- Minimal funding for the Fission Surface Power (FSP) and Nuclear Electric Propulsion projects, impacting the technology development needed for Artemis and risk delaying the timeline for living and working sustainably on the lunar surface
- Cancellation of ongoing Technology Maturation projects, impacting NASA's ability to deliver critical mission needs and to do meaningful technology research and development activities, and delaying delivery of surface technologies by approximately 1 year;
- Inability to award new Early Stage Innovation proposals, impacting university partners conducting technology research and development;
- Cancellation of the 2023 Announcement of Collaboration Opportunity (ACO) solicitation, rendering NASA unable to award and initiate new ACO projects, further impacting partnerships with industry and support to Artemis and science mission needs;

Greater impacts to critical technology development should be expected if STMD is funded below the FY 2023, \$1.2B, level, leading to cancellation of additional ongoing projects with strong industry partnerships.

Question 2. What would be the impact to NASA's programs and infrastructure of falling below the growth rate requested by the President's budget request over the next five years?

Answer. Cuts to the Science budget request could result in delay or cancellation of multiple missions currently in formulation. Lower than expected budgets will likely impact NASA's ability to issue new competitive opportunities across Science

Divisions, impacting science communities across the country and their progress on critical research.

Any cuts to the Exploration Systems Development budget request would impact NASA's ability to carry out the Moon to Mars lunar program. After the success of the Artemis I mission, NASA is at a critical juncture for human spaceflight. Significant efforts are underway to execute the Artemis II, Artemis III, and Artemis IV missions, all planned to occur within the next 4 years.

Reductions from the FY 2024 budget request could result in delays to the Artemis IV launch. Artemis IV will initiate the sustained lunar operation model with Gateway's delivery to lunar orbit, initial Gateway expansion with International Habitat through the international partnership with the European Space Agency, and demonstration of sustained Human Landing System docking with Gateway for crew exchange and continued exploration of the lunar surface.

Reductions could also force the Agency to terminate or not award contracts for new and ongoing systems production and development to support work on Artemis V and beyond. This could include not issuing planned awards for the Lunar Terrain Vehicle that would support mobile Lunar exploration and portions of the SLS and Orion production contracts for Artemis V and beyond. These actions could result in contractor layoffs. NASA could also be forced to halt/delay any Mars development efforts.

In the area of Space Operations, cuts to the budget request could delay the procurement of the U.S. Deorbit Vehicle (USDV), potentially slipping the date of its availability to safely deorbit the International Space Station (ISS) in 2030. Reductions in funding to the Commercial LEO Development (CLD) program would delay the operational availability of one or more platforms NASA would otherwise use to continue its important exploration research efforts in LEO after the deorbiting of ISS and avoid a gap in U.S. human presence. Finally, a reduction in space station operations funding could require NASA to fly fewer crew and cargo missions to ISS, which would result in a reduction in the amount of research and utilization on orbit. In addition, budget reductions will impact the ability of the Space Communications and Navigation (SCaN) program to fully support Artemis and Science community missions, as well as address infrastructure shortfalls.

Reduced funding for aeronautics could force NASA to cut investments in cutting-edge aviation technologies that will increase the speed, efficiency, and safety of air travel, and significantly reduce emissions.

Reductions from the budget request would curtail technology development with commercial partners intended to increase U.S. space capabilities, stimulate the U.S. economy, and create jobs.

NASA may be forced to reduce awards to Space Grant and other space STEM-related programs that educate our Nation's next generation of scientists, engineers, and explorers, decreasing participation by an estimated one million students and educators.

The FY 2024 request provides needed funding for critical infrastructure needs. If the requested funding level is not sustained, NASA would be severely limited in its ability to right size its infrastructure portfolio and improve the overall health and reliability of its facilities and assets through the Agency Master Plan. There would also be a continued growth of NASA's Deferred Maintenance, with the most recent estimate growing to over ~\$3.0B, the highest level ever.

Question 3. Administrator Nelson, can you update us on the standing up of the new program office and implementing its Congressional requirements? Can you also explain how the office intends to incorporate capabilities provided by Artemis mission partners into the overall Moon to Mars architecture?

Answer. The new Moon to Mars Program Office was established within the Exploration Systems Development Mission Directorate at NASA Headquarters on March 30, 2023. As directed by the 2022 NASA Authorization Act, the Moon to Mars Program Office focuses on hardware development, mission integration, and risk management functions for programs critical to the Agency's exploration approach that uses Artemis missions at the Moon to open a new era of scientific discovery and prepare for human missions to Mars. This includes the Space Launch System rocket, Orion spacecraft, supporting ground systems, human landing systems, spacesuits, Gateway, and more related to deep space exploration. The new office will also lead planning and analysis for long-lead developments to support human missions to Mars. Through our international and public-private partnerships, NASA will leverage capabilities provided by mission partners to build a sustainable Artemis architecture that creates a lunar exploration plan and establishes a clear path to the human exploration of Mars.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. AMY KLOBUCHAR TO
HON. BILL NELSON

Growing the STEM Workforce

For NASA to continue to innovate, we need to attract the next generation of engineers, inventors, chemists, biologists, astronauts, and so much more. That means ensuring that all American students receive the best training and education to compete with other economies around the world.

Question 1. How is NASA leveraging its budget to build a more diverse STEM workforce, expanding K–12 student engagement, and building partnerships in the technology sector?

Answer. NASA makes vital investments toward building a diverse Science, Technology, Engineering, and Mathematics (STEM) workforce. Our STEM engagement endeavors to attract, engage, and educate students and to support educators and educational institutions. Given the Nation’s need for a skilled STEM workforce and projected demand, NASA clearly has a vested interest in attracting, engaging, and preparing its future STEM professionals. The national STEM ecosystem will benefit from NASA contributions to attract and retain students on STEM pathways, with increased attention on underserved and underrepresented students.

NASA implements strategies to broaden student participation to increase diversity, equity, inclusion, and accessibility (DEIA) in STEM through NASA opportunities and activities. While the number of women and underrepresented minorities earning STEM degrees has grown in broad science and engineering occupations over the last decade, significant underrepresentation remains in areas critical to NASA such as engineering and computer and mathematical sciences. NASA is committed to building a diverse, skilled future STEM workforce—our next generation of explorers with the technical skills needed to carry forward our Nation’s vital mission and work in aeronautics and space into the future.

Additional steps to improve STEM engagement among underrepresented students include the recent funding of more than \$5 million to seven Women’s Colleges and Universities (WCUs) to research and develop strategies that increase retention of women in STEM degree programs and careers. The agency’s Minority University Research and Education Project (MUREP) created the Women’s Colleges and Universities opportunity to help women overcome obstacles and barriers to working in the fields of science, technology, engineering, and math. This award seeks to address the significant national gender gap and disparate experiences of women in STEM in the United States, both in higher education and the workforce. This funding opportunity asked Women’s Colleges and Universities to take advantage of their expertise by developing programs that encompass academics, research, student support, college prep, career prep, mentoring, and more. NASA explores the unknown for all, and values diversity, equity, inclusion, and accessibility for the future STEM and agency workforce.

Food Security/Agriculture

NASA has been at the forefront of applying Earth observation to address critical agricultural and food security challenges facing our farmers, ranchers, and food systems. NASA has partnered with the USDA to provide publicly available satellite images to estimate global growing conditions, such as soil moisture.

Question 2. Do you agree that making this kind of data available to farmers can improve soil health and boost productivity?

Answer. NASA, in partnership with the USDA, helps farmers and the agriculture industry in a variety of ways. For example, NASA’s soil moisture data enables the assessment of existing conditions and the extent to which these conditions are localized or regional. Farmers and the agriculture industry integrate this information into groundwater models and crop models that use multiple NASA and ground observations (*e.g.*, evapotranspiration, precipitation, ground and surface water supply, vegetation health). Integrating these data advances the agriculture communities’ ability to provide crop condition forecasts, assess the risk of flash drought, provide irrigation decision support, and provide fertilizer management for efficient applications to reduce costs and protect the environment. This information enables farmers to assess whether farm management practices are improving soil health and supports efforts to maintain or improve crop yields.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. KYRSTEN SINEMA TO
HON. BILL NELSON

NEO Surveyor Mission

Thank you for your time and insights during the NASA FY24 budget hearing earlier this month. I was particularly grateful for our productive exchange on the NEO Surveyor mission and the critical role it plays in planetary defense. As you know, I have strongly supported funding for this mission in the past and want to ensure it is funded adequately this year and in the future to ensure it remains on track for the March 2028 deadline. I was very happy to hear NASA remains confident of that timeline and that the mission is a priority.

As you also know, since the hearing a bipartisan compromise agreement to raise the Nation's borrowing limit and make changes to the Federal budget has been released. Specifically, the proposed text of H.R. 3746, the Fiscal Responsibility Act of 2023, would cap non-defense discretionary spending at \$703.7B for FY2024 and \$710.7 for FY25. This would impact Federal agencies across the board, including NASA.

Question 1. Can you commit to maintain the NEO Surveyor mission as a NASA priority this year and into the future, including as discussed at the hearing and in the FY24 budget request, so that the mission remains on target to launch in 2028 and achieve its goals?

Answer. In November 2022, NASA approved the NEO Surveyor mission to proceed into implementation with a committed launch date of no later than June 2028. The FY 2024 President's Budget Request supports that development schedule, and the mission is on track for launch. The main goal of the NEO Surveyor mission is to find two-thirds of potentially hazardous asteroids >140 meters within 5 years, and >90 percent of these in 10 years; the latter of which would fulfill the George E. Brown, Jr. Near-Earth Object Survey as contained in the NASA Authorization Act of 2005 (P.L. 109–155).

Budgetary Compromise

In the FY24 budget request NASA set clear priorities for the agency to advance science, plant new boot prints on the Moon, and continue the study of climate change here on Earth, among other important initiatives. Although the ultimate contours of any budget compromise legislative remain to be finalized, it is inevitable that spending caps for FY24 and FY25 will have some impact on NASA.

Question 2. Given this reality, are there are any general or specific areas of concern that you were unable to or that now differ from what you presented at the hearing? Are there particular programs or initiatives that must be prioritized or adjusted in light of this?

Answer. Cuts to the Science budget request could result in delay or cancellation of multiple missions currently in formulation. Lower than expected budgets will likely impact NASA's ability to issue new competitive opportunities across Science Divisions, impacting science communities across the country and their progress on critical research.

Without the levels of investment proposed in the Science budget request, NASA will struggle to move toward launching the complementary missions in its Earth System Observatory and undertake cutting-edge science necessary to assess a rapidly changing climate and mitigate natural hazards..

Cuts to the Exploration Systems Development budget request would impact NASA's ability to carry out the Moon to Mars lunar program. After the success of the Artemis I mission, NASA is at a critical juncture for Human Spaceflight

Significant efforts are underway to execute Artemis II, Artemis III, and Artemis IV missions, all planned to occur within the next 4 years.

Reductions from the FY 2024 budget request could result in substantial delays to the Artemis IV launch. Artemis IV will initiate the sustained lunar operation model with Gateway's delivery to lunar orbit, initial Gateway expansion with International Habitat through the international partnership with the European Space Agency, and demonstration of sustained Human Landing System docking with Gateway for crew exchange and continued exploration of the lunar surface. Reductions could also force the Agency to terminate or not award contracts for new and ongoing systems production and development to support work on Artemis V and beyond. This could include not issuing planned awards for the Lunar Terrain Vehicle that would support mobile Lunar exploration and some portion of the SLS and Orion production contracts for Artemis V and beyond. These actions could result in contractor layoffs. NASA could also be forced to halt/delay any Mars development efforts.

Reductions could result in decreased investments in cutting-edge aviation technologies that will increase the speed, efficiency, and safety of air travel, and significantly reduce emissions.

Reductions from the budget request would curtail technology development with commercial partners intended to increase U.S. space capabilities, stimulate the U.S. economy, and create jobs.

NASA may be forced to reduce awards to Space Grant and other space STEM-related programs that educate our Nation's next generation of scientists, engineers, and explorers.

The FY 2024 request provides needed funding for critical infrastructure. If the requested funding level is not sustained, NASA would be severely limited in its ability to right-size its infrastructure portfolio and improve the overall health and reliability of its facilities and assets through the Agency Master Plan. There would also be a continued growth of NASA's Deferred Maintenance, with the most recent estimate growing to over ~\$3.0B, the highest level ever.

Approximately 82 percent of NASA's infrastructure is beyond its design life, posing an elevated and rising risk to current and future missions. The result is NASA's infrastructure being run to failure rather than being repaired prior to failure when risk of failure is high.

Commercial Space and Workforce

The Moon to Mars program, established under the CHIPS and Science Act, sets an ambitious goal to take the sustainability efforts in Low Earth Orbit and the Moon and translate them into a sustainable presence on Mars. The program will also provide an inspiration to future scientists and engineers to pursue careers in space, technology, engineering, and mathematics.

Question 3. How will NASA help the commercial industry recruit and retain the robust and diverse workforce necessary to sustain this vision to set and complete ambitious goals for decades to come?

Answer. A robust pipeline of skilled space workers is critical to achieving NASA's goals in LEO, cis-lunar space, and beyond. NASA is working with the National Space Council, industry, and local partners to develop pilot programs that would improve the pipeline of skilled technical workers to the space industry. These programs will also partner with academia to target technology gaps that market forces would not otherwise fill.

Question 4. What role do you believe the commercial industry must play in inspiring future scientists and engineers to pursue rewarding, enduring space related careers? What can Congress do to ensure NASA has the resources to be a productive partner in these efforts?

Answer. Contracting services from industry partners allows NASA to leverage commercial innovation and provide the best value to U.S. taxpayers while achieving our exploration and science goals. These partnerships also provide more opportunities for inspiring and exciting careers in the commercial space industry. By funding these programs, like the Commercial LEO Development program, Congress is supporting public-private partnerships that are developing systems and services for NASA's exploration efforts, as well as a broader space economy with many participants.

Commercial Suborbital Crew Systems

NASA's FY24 budget request states that in FY24 "NASA will begin to leverage commercial suborbital crew systems to fly NASA personnel to perform microgravity research and other testing and qualification for spaceflight hardware, as well as conduct astronaut training." Commercial vehicles offer NASA safe, reliable, and cost effective access to suborbital space.

Question 5. Could you please provide an update on status and next steps for the program?

Answer. The Suborbital Crew (SubC) activity will let NASA personnel take advantage of commercial suborbital vehicles to meet the Agency's microgravity research needs. NASA is currently focusing on the potential of crewed suborbital vehicles for scientific research and technology development. Suborbital vehicles can provide longer periods of microgravity for experiments than either drop towers or parabolic aircraft flights. While NASA does not plan to flight-certify the suborbital systems it uses the way it certified orbital Commercial Crew Program vehicles, we are working to ensure a thorough understanding of the safety of suborbital launch systems. Our current effort consists of conducting "deep dives" with vendors—including Blue Origin and Virgin Galactic—on their systems. Once we are satisfied with the safety of these vehicles, we will begin to leverage commercial suborbital crew systems to fly NASA personnel to perform microgravity research and other testing and quali-

fication for spaceflight hardware. NASA currently provides funding for outside researchers to fly suborbital vehicles through its Flight Opportunities program. Using commercial systems to conduct its research will continue NASA's effort to enable a robust space economy.

Question 6. Can NASA commit to ensuring there is no gap between the ISS and Commercial LEO Destinations (CLD) program operation and to letting Congress know if there is anything NASA needs to make the CLD program successful?

Answer. NASA's goal is to align the ISS transition with CLD availability to ensure uninterrupted human presence in space. A commercial platform is expected to be available in the 2028 timeframe, enabling a two-year overlap with the ISS. The extension of ISS through 2030 was a critical part of the CLD strategy and helps to prevent an interruption in human presence in LEO. In taking a phased approach and maintaining competition, NASA expects to have one or more commercial platforms on orbit in time to transition from ISS to CLDs. Continued Congressional support is critical to the success of the CLD program.

Unmanned Aerial Systems

As you know, the CHIPS and Science Act directs NASA to research and test capabilities and concepts related to unmanned aerial systems.

Question 7. Do you have an update on the progress made here and does NASA have the resources necessary to meet this obligation?

Answer. NASA is jointly engaged with the FAA and industry to respond to the low altitude UAS Traffic Management Beyond Visual Line of Sight Advisory and Rulemaking Committee (UTM BVLOS ARC) recommendations. With the enacted FY 2023 appropriation for Aeronautics, NASA is jointly developing technologies with and delivering data to the FAA on three research transition products under the NASA FAA Research Transition Teams.

Under the FY 2024 President's Budget Request, NASA will jointly partner with FAA and industry to continue technology development and delivery of performance requirements and data to inform standards and procedures development for UTM BVLOS.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. RAPHAEL WARNOCK TO
HON. BILL NELSON

Sustainability

In November 2021, the United States released its Aviation Climate Action Plan, which outlined a commitment to reach net-zero greenhouse gas emissions from the U.S. aviation sector by 2050.¹ NASA has identified the adoption of Sustainable Aviation Fuels (SAFs), and their incorporation into its operations, as a key pillar of its efforts to achieve net-zero emissions.² Though the commercial aviation industry has begun incorporating SAFs into its operations, NASA's unique mission and operations are likely to present a special set of challenges for the adoption of SAFs, and ultimately a net-zero aviation economy.

Question 1. Does NASA anticipate the incorporation of SAF into its operations being the primary driver of emissions reduction across its various missions and programs? If not, what is expected to be the primary driver?

Answer. The 2021 Aviation Climate Action plan referenced in footnote 2 speaks to NASA's research and development efforts to help the aviation community achieve its net-zero emissions goals by 2050, rather than NASA's own operations. NASA has identified the adoption of Sustainable Aviation Fuels (SAF), along improved energy efficiency via aircraft design and operational approaches, as a key pillar in helping the aviation community achieve net-zero emissions by 2050. NASA has an important supporting role in SAF development, as well as a leadership role in the improvement of energy efficiency to enable reduced fuel use and emissions.

As with U.S. and global aircraft fleets, NASA's fleet will have to rely on SAF as the primary driver to reach net zero as SAF is, by definition, a drop-in conventional jet fuel replacement that can be used with existing aircraft. New, more energy efficient aircraft and operational approaches will be important to reducing required fuel amounts, costs and emissions but alone cannot achieve net zero.

Question 2. How much SAF does NASA currently use to support its missions and programs?

¹ https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

² <https://www.nasa.gov/aeroresearch/programs/iasp/sa/description/>

Answer. NASA has, in conjunction with both industry and the Department of Defense, conducted several tests and limited operations with multiple variants of bio-fuels. The amount of SAF used by NASA varies by test from year-to-year. For example: during a relatively large test planned for fall 2023, we anticipate using less than 75,000 gallons of SAF. NASA uses SAF when SAF is the key aspect of the research, such as studying changes in emissions characteristics from different SAF's compared to conventional jet fuel.

Question 3. How many gallons of SAF does NASA anticipate requiring annually in order to achieve net-zero emissions by 2050?

Answer. The amount required for NASA missions in 2050 would be negligible (as it is today) compared to the estimated 35 billion gallons that would be required by the U.S. commercial fleet to achieve net-zero emissions by 2050. Thus, if the U.S. can meet the demand of the U.S. commercial aviation with SAF then there will be enough for NASA operations.

Question 4. Has NASA identified a SAF pathway under ASTM D7566 that is most conducive for the agency's operations? If so, what is that pathway?

Answer. At present, NASA does not have a readily implementable or uniform method to support a comprehensive transition. Presently NASA would use whatever approved SAF pathway, of the 7 currently approved, is available local to its specific operations and that its budget would afford, noting that SAF is currently significantly more expensive than conventional jet fuel.

Diversity and Inclusion

People of color have played an important role in supporting NASA's missions and preserving American leadership in space. These individuals bring knowledge and expertise to science, technology, engineering, and math (STEM) fields that is critical to confronting emerging issues in space exploration. However, people of color continue to be underrepresented in STEM and NASA's work specifically. In February 2023, NASA announced grants to eight Historically Black Colleges and Universities through the Data Science Equity, Access, and Priority in Research and Education opportunity to enable students and faculty to conduct innovative data science research.³ These grants represent a positive step towards improving STEM engagement among underrepresented students, but there is more work to do.

Question 5. What additional steps is NASA taking to improve STEM engagement among underrepresented students and how have the agency's efforts improved upon previous initiatives?

Answer. NASA makes vital investments toward building a diverse Science, Technology, Engineering, and Mathematics (STEM) workforce. Our STEM engagement programs endeavor to attract, engage, and educate students and to support educators and educational institutions. Given the Nation's need for a skilled STEM workforce and projected demand, NASA clearly has a vested interest in attracting, engaging, and preparing its future STEM professionals. The national STEM ecosystem will benefit from NASA contributions to attract and retain students on STEM pathways, with increased attention on underserved and underrepresented students.

NASA implements strategies to broaden student participation to increase diversity, equity, inclusion, and accessibility (DEIA) in STEM through NASA opportunities and activities. While the number of women and underrepresented minorities earning STEM degrees has grown in broad science and engineering occupations over the last decade, significant underrepresentation remains in areas critical to NASA such as engineering and computer and mathematical sciences. NASA is committed to building a diverse, skilled future STEM workforce—our next generation of explorers with the technical skills needed to carry forward our Nation's vital mission and work in aeronautics and space into the future.

Additional steps to improve STEM engagement among underrepresented students include the recent funding of more than \$5 million to seven Women's Colleges and Universities (WCUs) to research and develop strategies that increase retention of women in STEM degree programs and careers. The agency's Minority University Research and Education Project (MUREP) created the Women's Colleges and Universities opportunity to help women overcome obstacles and barriers to working in the fields of science, technology, engineering, and math. This award seeks to address the significant national gender gap and disparate experiences of women in STEM in the United States, both in higher education and the workforce. This funding opportunity asked Women's Colleges and Universities to take advantage of their ex-

³ <https://www.nasa.gov/press-release/nasa-awards-millions-to-historically-black-colleges-universities>

peritise by developing programs that encompass academics, research, student support, college prep, career prep, mentoring, and more. NASA explores the unknown for all, and values diversity, equity, inclusion, and accessibility for the future STEM and agency workforce.

Question 6. What percentage of NASA's research expenditures are going to Historically Black Colleges and Universities and how have these funding levels changed in recent years?

Answer. NASA's Minority University Research and Education Project (MUREP) is expanding NASA's reach in communities historically underrepresented in STEM by offering opportunities for college students at Minority Serving Institutions (MSIs) to contribute to the agency's exploration goals and boosting these schools' research capacity and infrastructure. Through MUREP's competitive awards, research opportunities, and engagements at career fairs and conferences throughout the year, NASA is investing in the Artemis Generation and a diverse future workforce. MUREP's array of opportunities are available to Historically Black Colleges and Universities (HBCU), Hispanic-Serving Institutions, Asian American and Native American Pacific Islander-Serving Institutions, Alaska Native and Native Hawaiian-Serving Institutions, American Indian Tribal Colleges and Universities, Native American-Serving Nontribal Institutions, and other MSIs.

MUREP is one of four Congressionally appropriated projects in NASA's Office of STEM Engagement. In FY 2018, MUREP received \$32M, which was 32 percent of NASA's OSTEM budget of \$100M. In FY 2023, MUREP received \$45.5M, which was 31.7 percent of NASA's OSTEM budget of \$143.5M. Therefore, over the last five years, MUREP's funding levels, as a percentage, have remained steady. NASA MUREP funding to HBCUs has seen a significant increase from FY 2019 to FY 2022. In FY 2019, NASA provided \$6.8M to HBCUs, and this amount increased to \$13.9 M in FY 2022.

Stakeholder Engagement in NASA Exploration

NASA works with many educational institutions, companies, and government agencies in its space exploration efforts. Institutions of higher education in Georgia, like the Georgia Institute of Technology and the University of Georgia, have established strong relationships with NASA to expand our understanding of space and build the pipeline of future NASA employees. Georgia also has a robust and growing aviation and aerospace engineering and manufacturing sector that has worked with NASA in many of its missions.

Question 7. How does NASA envision integrating institutions such as universities, companies, and other government agencies into an overall cislunar exploration program?

Answer. As NASA embarks on a new era of lunar exploration through the Artemis missions, it is more important than ever that today's students—the Artemis Generation—have opportunities to flex their STEM skills and tackle some of the most critical technological challenges ahead. NASA is committed to inspiring the students of the Artemis Generation and supporting the educators and caregivers who guide them to discover their own unique skills, interests, and capabilities. By investing in today's students, we are building the highly capable, diverse STEM workforce our Nation will need to accomplish our long-term goals in aeronautics and space exploration. A couple examples of connecting the Artemis Generation to NASA include:

NASA's Next Gen STEM project produced a variety of resources to help educators excite the Artemis Generation about humanity's return to the Moon. The Artemis Camp Experience Guide, a set of hands-on activities telling the story of the Artemis missions, reached more than 100K people. Through the Artemis Generation Spacesuits and Build, Launch, Recover educator guides, students will learn all about the development of spacesuits and find out how NASA prepares for launch and recovers the spacecraft when its mission successfully ends.

Authentic, hands-on learning experiences give students a chance to test out their ideas and gain a whole new perspective on their own abilities. These student challenges and competitions are designed to spark the curiosity and determination of the Artemis Generation as they take on the challenges of space exploration. Challenges are available for students in middle school all the way through graduate school.

NASA recognizes the critical importance of integrating a wide variety of institutions in its goal of bridging technology gaps and delivering innovative solutions to our cis-lunar missions.

Through robust partnerships with universities, private companies, and other government agencies, we strive to ensure American leadership in aerospace while developing, demonstrating, and transferring new space technologies that benefit NASA, commercial, and other government missions.

NASA utilizes various mechanisms to engage external institutions, including but not limited to: Space Technology Research Grants (STRG's), Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) awards, NASA Innovative Advanced Concepts (NIAC), Center Innovation Funds (CIF), Tipping Point (TP) and Announcement of Collaboration (AOC) opportunities, the Flight Opportunities program (TechFlights), and the Game Changing Development (GCD) program. Information about these and other funding/partnership opportunities can be found at <https://techport.nasa.gov/opportunities>.

In the state of Georgia, NASA has a strong partnership with the Georgia Institute of Technology as a lead Space Technology Research Institute (STRI) in the area of high-power electric propulsion systems. In addition to Georgia Tech, NASA works with the University of Georgia, and Clark Atlanta University on various technologies that will advance NASA's capabilities in cislunar space such as habitat optimization; terrain relative navigation, additive manufacturing, and in-space manufacturing. Through the SBIR program, STMD is working with the Global Technology Connection, Inc. of Atlanta, GA on data acquisition systems.

Question 8. How can Congress support NASA in working with stakeholders to grow student engagement in space exploration and build the agency's workforce pipeline to include more individuals from underrepresented communities?

Answer. Congressional support for the FY 2024 President's budget request would enable NASA to grow student engagement and make vital investments toward building a diverse Science, Technology, Engineering, and Mathematics (STEM) workforce. NASA's STEM engagement programs endeavor to attract, engage, and educate students and to support educators and educational institutions. Given the Nation's need for a skilled STEM workforce and projected demand, NASA clearly has a vested interest in attracting, engaging, and preparing its future STEM professionals. The national STEM ecosystem will benefit from NASA contributions to attract and retain students on STEM pathways, with increased attention on underserved and underrepresented students. Recent national and international tests show that in the last decade, U.S. students have demonstrated little or no growth in mathematics and remain ranked in the middle of advanced economies on international science and mathematics assessments.

NASA implements strategies to broaden student participation to increase diversity, equity, inclusion, and accessibility (DEIA) in STEM through NASA opportunities and activities. While the number of women and underrepresented minorities earning STEM degrees has grown in broad science and engineering occupations over the last decade, significant underrepresentation remains in areas critical to NASA such as engineering and computer and mathematical sciences. NASA is committed to building a diverse, skilled future STEM workforce—our next generation of explorers with the technical skills needed to carry forward our Nation's vital mission and work in aeronautics and space into the future.

NASA is committed to inspiring the students of the Artemis Generation and supporting the educators and caregivers who guide them to discover their own unique skills, interests, and capabilities. By investing in today's students, we're building the highly capable, diverse STEM workforce our Nation will need to accomplish our long-term goals in aeronautics and space exploration.

Artemis Program

The Artemis program represents NASA's strong exploration goals of establishing a sustainable presence on the Moon to prepare for missions to Mars. The CHIPS and Science Act of 2022 (P.L. 117-167) provides tremendous support for NASA to continue making progress on Artemis and further human exploration beyond low-Earth orbit. The success of the Artemis I mission and the start of training for the Artemis II crew mark positive steps in pursuit of this goal. Despite strong progress by NASA, potential challenges to future success of the Artemis program have been raised. In its 2022 annual report, the NASA Aerospace Safety Advisory Panel raised NASA's safety culture as an area in need of improvement.⁴ The Panel used Artemis I as a case to represent NASA's need to facilitate better safety culture and encourage safety engagement from all levels of the agency. The Panel also noted that there is the potential for a significant reduction in the size and experience level of the NASA workforce following the completion of the Artemis I mission.

Question 9. What are the biggest challenges to sustaining the Artemis moon missions going forward?

Answer. Anything less than the FY 2024 requested funding for Exploration Systems Development will pose significant, adverse impacts to Artemis Missions. Sig-

⁴<https://oir.hq.nasa.gov/asap/reports.html>

nificant content is currently in work to build upon the success of Artemis I with the Artemis II, III, and IV missions all planned to occur within the next four years. A topline reduction for exploration could force NASA to terminate, or significantly restructure, major development work such as Gateway, development of SLS Block 1B Exploration Upper Stage, EGS's Mobile Launcher-2, and HLS Option B contract. These actions could involve significant layoffs throughout the ESDMD contract structure. This could potentially endanger NASA's ability to achieve Artemis IV goals, the overall ability to deliver heavy lift capability, and could stop lunar exploration beyond Artemis IV.

Question 10. How does NASA plan on facilitating a more proactive safety culture among all levels of the agency?

Answer. The NASA has a proactive and robust Safety Culture Program, whose key elements include assessment, education, and engagement of the NASA workforce.

NASA's Safety Culture is driven from the top down, from policy to practice. Our most recent survey responses from over 26,000 government and contractor employees show strong positive perceptions of safety culture with an average score of over 5 on a 6 points scale on all items.

Survey debriefs, led by the NASA Administrator, were held with major head of organizations and discussed with all NASA executives.

Safety Culture educational course, available to all employees and contractors, has been taken by more than 33,000 government and contractor employees, covering topics such as how to report and respond to safety concerns. NASA hosts an annual safety event alongside the Agency's Day of Remembrance. All new NASA executives are required to participate in the Executive Safety Leadership Panel, a multi-day, immersive experience to truly deepen every leader's appreciation for safety culture.

