

**COMMERCE, JUSTICE, SCIENCE, AND RE-
LATED AGENCIES APPROPRIATIONS FOR
FISCAL YEAR 2021**

WEDNESDAY, SEPTEMBER 23, 2020

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:02 p.m., in room SR-325, Russell Senate Office Building, Hon. Jerry Moran (Chairman) presiding.
Present: Senators Moran, Boozman, Shaheen, Manchin, and Van Hollen.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OPENING STATEMENT OF SENATOR JERRY MORAN

Senator MORAN. The Subcommittee on Commerce, Justice, Science, and Related Agencies will come to order.

Good afternoon. I am happy to call this hearing to order, and we are pleased to be able to hear from the Administrator today. Welcome to the Commerce, Justice, Science Subcommittee hearing with the National Aeronautics and Space Administration. Our witness today is the NASA Administrator, James Bridenstine. I thank you for being here in these difficult times. I can almost see you across this room, but we are delighted that you are with us here in the old Senate Russell Building in this historic room.

Before we get into details, I just want to take a moment to acknowledge last week's dedication of a presidential memorial to President Eisenhower. It occurred here in Washington, D.C. It was dedicated last Thursday, and it was President Eisenhower that made a recommendation in 1958 for the Nation's space agency to be a civilian-based entity. Congress responded by taking activities of the National Advisory Committee for Aeronautics and transforming them into NASA. I pay tribute to this native Kansan and appreciate the decision that was made then.

Since that time, since 1958, NASA has become known around the world as the leader in innovation and exploration, inspiring generations of engineers, developers, and explorers. And I want to commend you, Administrator Bridenstine, Vice President Pence, and the Trump administration for continuing that inspiration with bold vision, historic accomplishments, and focus on returning astronauts to the Moon with the Artemis program.

On Monday, NASA released their Lunar exploration program overview, which integrates the elements needed to return our as-

tronauts to the surface of the Moon with the science goals we hope to achieve. I look forward to that announcement being discussed, learning more details. I am glad you are here and the timing that your presence here lends importance to this hearing.

I plan on today's hearing being the first in an ongoing dialogue with NASA and others to explore the Artemis program and the impact it will have on our country. In my view, it goes without saying the significant impact the Apollo program had on our Nation, and we continue to reap benefits of those missions, and I anticipate that Artemis will do the same for years to come. Much like Apollo, Artemis has the potential to influence our daily lives from the advancements in science and technology to inspire the next generation of leaders.

The fiscal year 2021 budget request for NASA contains a total of \$12 billion associated with the Artemis program efforts toward landing astronauts on the Moon in 2024. This plan includes the building and testing of rockets, capsules, and the development of lunar landers that will deliver a crew to the surface of the Moon. I am excited about the potential of the first woman being on the Moon.

However, our world has been significantly altered since the initial release of the budget, and I look forward to discussing how NASA is adapting our new and unprecedented environment while pushing forward with Artemis. Although we face many challenges, including COVID-19, I am interested in hearing your testimony today and discussing the value of the Artemis program and what it will bring to our Nation and to the world. These are unique times, and I look forward to hearing how NASA is planning to address them, and I again thank you, Mr. Administrator, for being with us here today.

I now recognize the Ranking Member of our subcommittee, Senator Shaheen, for her opening remarks.

OPENING STATEMENT OF SENATOR JEANNE SHAHEEN

Senator SHAHEEN. Well, thank you very much, Chairman Moran. Thank you to Administrator Bridenstine for being here this afternoon.

I have a little longer statement than usual as an opening, and while I would echo your positive comments about former President Eisenhower and his commitment to the space program and making sure that was a civilian agency, I want to express my concerns about where we are with respect to the appropriations process, Mr. Chairman.

Next week is the end of the fiscal year. You and I worked together on a bipartisan bill. We had that ready to move forward in June. But when the fiscal year ends, the Senate Appropriations Committee will not have held one single markup. No bills will have been reported to the Senate.

We have already gone 4 months—more than 4 months—since the House sent us the HEROES Act without really addressing the needs of Americans who are suffering from this pandemic and the economic consequences of COVID-19. We have so many who have lost jobs that are directly linked to the inaction of this government and delays in the Senate.

For example, in 2 weeks, the State Department will eliminate nearly 200 jobs from the National Passport Center in Portsmouth, New Hampshire, and these cuts are the result of lost revenue from fees during the COVID-19 pandemic. Yet, the administration and Majority Leader McConnell refuse to move forward with any comprehensive legislation that can help restore these jobs and others.

I think we should finish the continuing resolution. Obviously, all of us want to keep this government open, but we should also have enough capacity to work together to pass a comprehensive bipartisan COVID-19 relief package. I think that is long overdue. We should have done it before we left in August. We should do it before we leave for the election.

Now, turning to the subject of today's hearing, the last time I was with the Administrator was a virtual roundtable that we held to help small businesses in New Hampshire take part in NASA's programs. As I said to you, Administrator, I very much appreciated your willingness to join us on that, and we had a lot of enthusiasm and support from small businesses in the State who I hope will continue to be able to work with NASA.

We heard on that Zoom some of the excitement of the shared vision of returning humans to the Moon, and I was really pleased to hear that. I have heard a lot of excitement among young people in particular about that.

Of course, we know that NASA needs to be about more than just a single Moon shot, that it should also support science that teaches us about the Earth, our solar system, the Sun, and the universe. NASA should develop technologies that further not just human exploration but also NASA's other important missions. Most of all, NASA should inspire and teach students.

However, while the budget before us includes a generous 12 percent increase, it is focused on achieving one Moon landing by 2024. In order to do so, it proposes to eliminate NASA's Science, Technology, Engineering, and Math engagement program. It also cuts NASA's next generation transportation systems and science, canceling, among other projects, a telescope that NASA had renamed earlier this year to honor pioneering scientist, Nancy Grace Roman.

To me what is so frustrating is that these proposals are not new. Congress on a bipartisan basis has rejected these efforts to cut science programs in NASA for the last 3 years.

The administration has ambitious plans to return to the Moon rely on having a technically literate science and engineering workforce. That is why I believe that this subcommittee is not going to eliminate NASA education programs. The New Hampshire Space Grant is inspiring a love of science in K through 12 students and helping to support undergraduates and graduate students through scholarships, fellowships, and internships. Research grants and education programs like Space Grant and EPSCoR help make every State a space State.

New Hampshire, I am pleased to say, is a space State. Since the first American in space, Alan Shepard, who came from New Hampshire, and of course, our teacher in space, Christa McAuliffe who died tragically in the Challenger accident, to today's New Hampshire companies and universities who supply NASA with technology to improve both low-Earth orbit and deep space exploration

and design, build and operate major instruments on NASA satellites to study space and solar physics, the Moon, and the Earth.

I look forward to working with you, Chairman Moran, and to ensure that we can pursue sending humans to the Moon and Mars without sacrificing other important NASA missions.

Again, Administrator Bridenstine, thank you for being here today.

Senator MORAN. Senator Shaheen, thank you for your opening statement. I would indicate to you and to others that it is a privilege to be able to work with you on this subcommittee and many other things in the United States Senate.

I certainly share your views in regard to getting us out of a continuing resolution and completing our work on 12 appropriations bills. You are right. You and I have attempted to—we have actively pursued that goal in the past and continue to do so this year. We are in a circumstance in which the CR is now necessary. I have indicated so many times I am never voting for a CR again, but then the alternative becomes shutting down government, and that is a worse alternative.

Senator Shaheen, I pledge to you—I have indicated to those who ask me about our work on this subcommittee and the Appropriations Committee I am convinced that you and I can present, with the work of our Committee Members on this subcommittee, a CJS Committee report, a subcommittee report, that would be accepted nearly unanimously by our colleagues, Republicans and Democrats, and would receive broad support on the Senate floor. We have the capability of delivering that product. We just need to be given the opportunity to do so.

I am certainly interested in seeing that we take the necessary steps to meet the needs of those who continue to suffer both from a health perspective and from an economic perspective from the consequences of COVID-19.

I appreciate you pointing out the importance of us as a subcommittee doing our work, the importance of the Senate and Congress and the White House reaching agreement so that we can complete 12 appropriation bills in an appropriate way.

I now recognize Administrator Bridenstine for his testimony, and then we will have a round of questions and answers thereafter. Administrator Bridenstine, thank you very much. Thank you for joining Senator Shaheen and I and other Members of the subcommittee, and we look forward to your testimony.

STATEMENT OF HON. JAMES F. BRIDENSTINE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BRIDENSTINE. Chairman Moran, Ranking Member Shaheen, it is great to be back here at the subcommittee. I know it has been a long time since we—and other Members of the subcommittee, it is good to see you. It has been a long time since we have had the ability to get together, and I know we are definitely distanced right now, but I feel very safe and I appreciate having the opportunity to come and testify before the subcommittee.

To start, I want to say thank you to everybody in this room for the CARES Act. This was a piece of legislation that was critically important for NASA to be able to continue its missions. I know ev-

everybody in the country watched with great interest as we launched American astronauts from American soil for the first time since 2011 just a few short months ago, and of course, we launched the Mars 2020 Perseverance Rover to Mars. Those things were available to us because of monies that helped us have personal protective equipment, monies that helped us as an agency continue to move forward with IT requirements to work remotely and do all of those things that are necessary in the COVID-19 era. Without the CARES Act, we could have probably done the missions but not nearly as safely as we were able to because of the CARES Act so, number one, thank you.

Second of all, the dialogue that I just heard is very important to the NASA workforce. The idea, I think Chairman Moran that you said, you know, CRs are not optimum, but they are better than the alternative. On behalf of 70,000 employees at NASA, civil servants, and contractors, we wholeheartedly agree with that assessment. We are grateful for acknowledging that and working to come to a resolution on a CR.

I will tell you that when we think about the value that NASA brings to the United States of America, we think about the economic value. I know a lot of people are maybe watching this on C-SPAN or maybe NASA TV or whatever the case is. They are probably watching maybe online. We think about Internet broadband from space. We think about satellite television. We think about XM radio. These are all space-based communication capabilities, and this type of capability was born from this little agency called NASA.

It is not just the way we communicate. It is the way we navigate, which has transformed how we live. It is the way we produce food, the way we produce energy, the way we understand climate, the way we predict weather, the way we do national security and defense, and of course, the way we do disaster relief. So the benefit to the United States Government from an agency like NASA leading the way I think is, quite frankly, immeasurable.

I will also tell you that the budget that we have before the House and the Senate today is a very strong budget, and I think it is a budget that ultimately enables us to continue to push forward humanity into the solar system in a way that we have never done before.

We think about going to the Moon, going sustainably, being able to stay and live and work on another world for long periods of time, using the resources of that world, the hundreds of millions of tons of water ice that were discovered back in 2009 and 2010, using that water ice for life support, and of course, the hydrogen, which is part of that water ice, for fuel. These are opportunities that are available to us today that we were not even thinking about back in the 1960s and 1970s. The idea that we are going to use the Moon as a proving ground, we learn how to live and work for long periods of time on the surface of another world, and we take all of that knowledge ultimately to Mars.

I think this is very exciting time at NASA. We think about the Science Mission Directorate at NASA and the value that the Science Mission Directorate is going to receive from the surface of the Moon and from orbit around the Moon. Heliophysics is a crit-

ical component of that. Astrophysics, planetary science, the Gateway which ultimately is going to enable us to travel with humans all the way to Mars.

I think the budget that is before the House and Senate appropriators right now is a very strong budget. Certainly, like any budget, we have to make difficult decisions when we go through the budget process, but I think that this is a budget that meets the requirements of the decadal surveys and it is a budget that I think all of America can be very proud of. Of course, as always, we stand ready to work with the lawmakers that appropriate the funds for the agencies like NASA that ultimately need to accomplish the objectives of our country.

With that, Mr. Chairman, I will yield back and avail myself to questions.

[The statement follows:]

PREPARED STATEMENT OF HON. JAMES BRIDENSTINE

OVERVIEW

Chairman Moran and Members of the subcommittee, I am pleased to have this opportunity to discuss NASA's fiscal year 2021 budget request. We are proposing a budget of \$25 billion, an increase of 12 percent over our request for fiscal year 2020. This budget both reinforces our innovative human space exploration program and maintains strong support for NASA science, aeronautics, and technology research. This investment, coupled with the unmatched talent of NASA's workforce, will enable America's continued leadership in space, propelling the United States toward a new era of technical achievement and scientific discovery.

Regarding the COVID-19 pandemic, I would like to assure you that keeping the NASA workforce safe has been our highest priority during this challenging period. Since mid-March, more than 90 percent of our workforce has been in a telework status, and our employees have continued to perform NASA's important missions with distinction. Only a limited number of employees performing mission-essential work for the protection and safe operation of critical Agency infrastructure and a few select missions (e.g., Commercial Crew Program Demo-2 launch and Mars Perseverance launch preparations) were authorized to be on site. The amazing productivity of our workforce during the pandemic has proven that more work could be done remotely in the future. We will use lessons learned in our "Future of Work" planning.

NASA's fiscal year 2021 request funds Artemis, the Agency's plan to land the first woman and the next man on the surface of the Moon in 2024 as part of a Moon to Mars campaign of exploration. Most urgently, the fiscal year 2021 request includes more than \$3 billion for the development of a Human Landing System (HLS). The budget fully supports the Space Launch System (SLS) rocket, Orion spacecraft, the Gateway, the ground systems, infrastructure, space technologies, and science needed for Artemis. The Moon to Mars campaign includes efforts from across the Agency funded at \$12.37 billion in fiscal year 2021. This budget provides the resources we need in fiscal year 2021 to send humans to the Moon in 2024. There, we will prove the technologies and systems for long-term exploration and utilization required to accomplish the great, national goal of sending humans to Mars. The Artemis missions are a key step to supporting human missions to Mars, and funding for Artemis at the levels requested is the best way to advance the timeline for these missions.

HUMAN EXPLORATION AND OPERATIONS

The request provides the fiscal year 2021 resources NASA's Human Exploration Operations Mission Directorate needs to support a robust exploration program. The fiscal year 2021 request includes \$8.76 billion for Deep Space Exploration Systems, and \$4.19 billion for Low-Earth Orbit and Spaceflight Operations, including the ISS and Space Transportation—both commercial crew systems development and ongoing crew and cargo transportation services that resupply the ISS.

NASA is building a deep space launch and crew system—the Orion spacecraft, the heavy-lift SLS launch vehicle, and the related Exploration Ground Systems (EGS)—to support the Artemis effort. NASA's plan to send the first woman and the next man to the surface of the Moon begins with two test flights: Artemis I and Artemis

II. Artemis I will use the SLS rocket to send an uncrewed Orion spacecraft around the Moon to test the system and reduce risk. Artemis II will be the first crewed mission and will serve to demonstrate the crewed system. Following these test flights, Artemis III will launch a crew of four using SLS and Orion on a mission to the surface of the Moon. Earlier this year, NASA completed a detailed cost and schedule assessment for the launch of Artemis I, which included a joint cost and schedule confidence level analysis of the SLS and EGS programs. Based on these results, NASA intends to target a November 2021 launch date for Artemis I. NASA is actively managing impacts to Artemis II based on the Artemis I schedule changes, and is currently planning to an August 2023 launch readiness date.

The Gateway in lunar orbit will be capable of supporting visiting vehicle docking, deployments, and operations. It will initially consist of the Power and Propulsion Element and the Habitation and Logistics Outpost. Once Gateway is launched and becomes operational in lunar orbit, the Gateway Logistics Element will deliver supplies for outfitting and surface expeditions. International partnerships in the Gateway will allow NASA to leverage habitation, robotics, and communications capabilities. The Gateway is a key aspect of the sustainability of the Artemis effort and future missions to Mars.

On April 30, 2020, NASA announced the selection of three U.S. companies to design and develop human landing systems for the Artemis program: Blue Origin of Kent, Washington; Dynetics (a Leidos company) of Huntsville, Alabama; and SpaceX of Hawthorne, California. NASA's partners will refine their concepts through the contract base period ending in February 2021. NASA will later select firms for development and maturation of sustainable lander systems followed by demonstration missions. NASA intends to procure commercial transportation services to the lunar surface.

At the lunar South Pole, NASA and our partners will develop an Artemis Base Camp to support longer lunar expeditions on the surface. The three proposed primary mission elements of Artemis Base Camp are: the Lunar Terrain Vehicle (unpressurized rover) to transport suited astronauts around the site; the habitable mobility platform (pressurized rover) that can enable long-duration trips away from Artemis Base Camp; and the foundation surface habitat that will accommodate four crew on the lunar surface and anchoring Artemis Base Camp and the U.S. presence at the South Pole. The Artemis Base Camp will demonstrate America's continued leadership in space and prepare us to undertake humanity's first mission to Mars.

As part of the Artemis effort, NASA will leverage interagency partnerships, expanding relationships with other U.S. Government agencies to take advantage of their expertise, create mutually beneficial synergies, and ensure ongoing coordination in the pursuit and achievement of the Nation's space goals. NASA will maintain and grow mutually beneficial international partnerships to lead a global community dedicated to expanding peaceful exploration and use of the Moon and then Mars.

The budget request continues support for the ISS, humanity's premier home in space over the last 20 years, and commercial cargo resupply services. NASA and our international and commercial partners are conducting critical research on ISS to support our future exploration plans while also supporting basic and applied research that exploits the unique microgravity environment in orbit. ISS supports cutting-edge research on the effects of spaceflight on the human body, as well as research in fluid physics, combustion, and other research areas.

NASA's Commercial LEO Development program will continue to leverage its resources and capabilities to further expand the commercial market in LEO. The program's first solicitation award, announced in January 2020, will support the development of a new commercial LEO platform that will initially be attached to the ISS Node 2 forward port. NASA also is seeking proposals from industry for partnerships that will demonstrate free-flying commercial destinations. Furthermore, NASA has opened the ISS for commercial activities, is encouraging private astronaut missions to the ISS, and is seeking other opportunities to partner with industry to stimulate demand for products and services in LEO. It is critically important for NASA to receive the full budget request for this program to ensure that there is no gap in U.S. presence in LEO and also to ensure NASA can continue meeting its microgravity research requirements after ISS retirement.

Through NASA's Commercial Crew Program, American astronauts have resumed launching to ISS from American soil for the first time since the Space Shuttle was retired in 2011. The May 30 launch of SpaceX's Dragon Endeavour Demo-2 marked the beginning of the second spaceflight test of the Crew Dragon craft and its first test with astronauts aboard. Astronauts Robert Behnken and Douglas Hurley conducted a successful mission to the ISS and returned safely to Earth on August 2. This was SpaceX's final test flight and is providing data on the performance of the Falcon 9 rocket, Crew Dragon spacecraft and ground systems, as well as in-orbit,

docking, splashdown, and recovery operations. NASA's SpaceX Crew-1 mission is slated for launch from the U.S. to ISS later this year. The crew for this historic mission will be comprised of three NASA astronauts, as well as an international partner astronaut from Japan.

Boeing is currently targeting no earlier than December 2020 for launch of the uncrewed Orbital Flight Test-2 (OFT-2) of its CSD-100 Starliner spacecraft, pending hardware readiness, flight software qualification, and launch vehicle and space station manifest priorities. Over the summer, Boeing's Starliner team focused on readying the next spacecraft for its upcoming flight tests as well as making improvements identified during various review processes throughout the beginning of the year. After a successful OFT-2, Boeing and NASA will fly Starliner's first crewed mission, the Crew Flight Test, currently targeted for no earlier than June 2021, with the first post-certification mission, called Starliner-1, tentatively scheduled for no earlier than late December 2021.

EXPLORATION TECHNOLOGY

NASA's fiscal year 2021 request includes \$1.58 billion for Exploration Technology. NASA is enabling technology research and development needs for human space exploration and Artemis, with a near-term prioritization of sustainable lunar surface exploration and exploration of Mars in the long-term. The Space Technology Mission Directorate (STMD) rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships. These transformative technologies enable NASA's lunar and deep space exploration missions to meet human space exploration needs, as well as foster commercial expansion in LEO, cislunar space, and beyond.

In direct alignment to Artemis and NASA mission needs, investment decisions are driven by the following Technology Thrusts: (1) rapid, safe, and efficient space transportation, emphasizing reusable in-space transportation between Earth, the Moon, Mars and beyond; (2) expanded access to diverse surface destinations, routinely landing crew and cargo on the Moon and eventually Mars; safely and efficiently returning large payloads to Earth; and delivering robotic payloads to challenging new destinations; (3) sustainable living and working farther from Earth, routinely conducting crewed operations beyond LEO working toward a sustainable human presence on the Moon and eventually Mars; technologies to survive and operate through the lunar night; production of propellant and consumables from local resources; and (4) transformative missions and discoveries to reach challenging sites and resources on the Moon, Mars and beyond, and enable rapid, low-cost missions to the Moon, Mars and beyond.

STMD is funding an array of efforts to accelerate NASA's broader Moon-to-Mars campaign: autonomous landing and hazard avoidance; advanced cryogenic fluid management capabilities; rapid and efficient transit propulsion; high-performance spaceflight computing; and advanced materials, and in-space manufacturing and assembly technologies. In the first year of the Lunar Surface Innovation Initiative, NASA kicked off the Polar Resources Ice Mining Experiment project by down-selecting a drill targeted for early lunar surface demonstration. STMD is also investing in an advanced Navigation Doppler LiDAR technology for precision landing on the Moon and other planets that will directly benefit future human and robotic landers. This technology will be demonstrated on the first two of NASA's robotic Commercial Lunar Payload Services (CLPS) missions. In addition, STMD will make strategic surface technology investments critical for future Moon and eventually Mars human missions.

The integrated Space Nuclear Technologies portfolio sets a new path forward to enable long-duration surface missions on the Moon and eventually Mars. This program places a high priority on lunar surface power, but also will continue to make progress on propulsion capabilities to meet the power and propulsion needs for the future exploration of Mars.

Upcoming early-stage innovation activities will investigate areas such as breakthrough propulsion, challenges in deep space human habitation, space-optimized energy systems, radiation protection, and materials. These areas are part of a comprehensive approach to efficiently support innovative discovery, progress toward important goals, and the development of exciting new capabilities.

SCIENCE

NASA's Science Mission Directorate funds ongoing discovery and exploration of our planet, other planets and planetary bodies, our star system in its entirety, our galaxy, and the universe beyond with domestic and international partners. The fiscal year 2021 budget supports Decadal Survey priorities identified by the science

community, including history's first Mars sample return mission, the Europa Clipper, and more advanced Earth observation missions. The request supports more than 110 space missions and approximately 10,000 U.S. scientists, and includes partnerships with 12 other Federal agencies and 60 other nations. The fiscal year 2021 budget request provides \$6.31 billion for Science, including: \$2.66 billion for Planetary Science; \$831 million for Astrophysics; \$414.7 million for the James Webb Space Telescope (JWST); \$633.1 million for Heliophysics; and \$1.77 billion for Earth Science. The budget request will enable NASA to continue advancing a world-class, balanced science portfolio while accelerating our exploration goals for the Moon and Mars.

NASA's Lunar Discovery and Exploration Program is working with several American companies to deliver science and technology to the lunar surface through the CLPS initiative. Under the Artemis program, early commercial delivery missions will perform science experiments, test technologies and demonstrate capabilities to help NASA explore the Moon and prepare for human missions. The first two CLPS launches are targeted for July 2021. This past June, NASA announced that it had selected Astrobotic of Pittsburgh to deliver NASA's Volatiles Investigating Polar Exploration Rover (VIPER) to the Moon's South Pole in late 2023. By searching for water ice and other potential resources, VIPER will help pave the way for astronaut missions to the lunar surface beginning in 2024 and will bring NASA a step closer to developing a sustainable, long-term presence on the Moon as part of the Agency's Artemis program.

In *Planetary Science*, the Mars 2020 Perseverance rover mission launched on July 30, and is on its way to the Red Planet to continue NASA's leadership in the international community and search for signs of ancient life and collect samples to send back to Earth. When it lands in February 2021, it will collect rock and soil samples at the landing site, Jezero Crater. As part of the mission, NASA will deploy the Ingenuity helicopter from the rover in the first demonstration of rotorcraft on another planet. Perseverance will cache samples to be collected by NASA's Mars Sample Return mission in partnership with the European Space Agency (ESA).

Planetary Science also supports: the next Discovery missions, Lucy and Psyche; the Europa Clipper mission, which will conduct over 40 fly-bys of this icy moon; and Dragonfly, a mission to Saturn's moon Titan, currently planned for launch in 2026. A new Near-Earth Object (NEO) Surveillance Mission—a follow-on to NEOWISE—will help NASA complete the Congressional goal to find NEOs at least 140 meters in diameter approximately 10 years after the mission begins on-orbit operations. The Double Asteroid Redirection Test, which will launch in July 2021 and deliberately crash into an asteroid moon in fall 2022, will conduct a planetary-defense-driven test of the kinetic impactor technique for preventing an impact of Earth by a hazardous NEO in the future; and NASA's first asteroid sampling mission, the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx), will touch the asteroid Bennu's surface during its first sample collection attempt, with return to Earth expected in 2023.

Astrophysics takes on the challenge of understanding the vast universe, using new technologies to look back in time to its origins and learn about the evolution of galaxies and stars. The fiscal year 2021 request will enable NASA to follow the decadal-survey-recommended cadence of Astrophysics Explorers; add a new small mission component (Pioneers) to this storied program; support competed missions and research; and continue the development of JWST, which is slated for launch in October 2021. The Hubble Space Telescope, launched and deployed 30 years ago this past April, is still producing incredible science. The Transiting Exoplanet Survey Satellite continues planet hunting as part of its extended mission, providing a growing list of worlds around nearby stars.

The next Decadal Survey on Astronomy and Astrophysics, Astro 2020, is currently underway and is scheduled for release by the National Academies of Science, Engineering and Medicine in 2021. NASA looks forward to the final recommendations and working to implement them.

In order to maintain a balanced science program that optimizes overall scientific return, the fiscal year 2021 budget request again proposes termination of the Nancy Grace Roman Space Telescope, given its significant cost and the need to prioritize spending. This request also includes \$12 million to begin closeout of the Stratospheric Observatory for Infrared Astronomy (SOFIA), which has annual operating costs of about \$80 million. SOFIA's annual budget is the second most expensive operating Astrophysics mission, and it is less scientifically productive than other missions with similar operating costs.

Heliophysics studies the fundamental properties of our star, the Sun, and how its behavior impacts Earth, our solar system, and the nature of space. This research helps scientists identify the causes and impacts of space weather phenomena, which

threaten spacecraft and astronauts, including future explorers of the Moon and Mars, and which can affect technology on and around the Earth. The fiscal year 2021 budget request supports the Heliophysics Space Weather Science and Applications Program and continued coordination with other agencies to enhance space weather prediction capabilities. Also supporting science in Artemis, Heliophysics is developing a space weather instrument suite for the Gateway.

Missions in the Heliophysics System Observatory continue to provide vital information about our Sun, including: Parker Solar Probe, which has now completed four trips close to the Sun; the Ionospheric Connection Explorer, and Global-scale Observations of the Limb and Disk instruments, which are providing comprehensive observations of Earth's ionosphere; and Solar Orbiter, a mission led by ESA, that is orbiting the Sun, looking at different regions from our other instruments.

Earth Science develops and operates a wide array of space-based and airborne missions seeking to improve our understanding of Earth. The fiscal year 2021 budget request supports a variety of missions, including the Orbiting Carbon Observatory-3 on ISS; the ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station instrument; and the Global Ecosystem Dynamics Investigation instrument. NASA also continues progress on Landsat 9, a part of the Sustained Land Imaging Program, planning for a launch in 2021.

In November 2020, NASA plans to launch Sentinel 6A Michael Freilich, a 10-year Earth observation mission, which partners with NOAA, ESA, the European Commission, and the European Organization for the Exploitation of Meteorological Satellites. Sentinel 6A Michael Freilich will measure Earth's changing oceans, providing valuable and long-running data on sea level, ocean circulation and key drivers of our weather, like El Niño and La Niña. In a remarkable gesture earlier this year, the partners renamed the mission after Michael Freilich, NASA's former director of Earth Science.

Consistent with the fiscal year 2019 and fiscal year 2020 budget requests, the fiscal year 2021 request does not support the Plankton Aerosol Cloud Ocean Ecosystem (PACE) and Climate Absolute Radiance and Refractivity Observatory Pathfinder (CLARREO-PF) missions. The PACE mission builds on the legacies of NASA missions currently on orbit and several international efforts. Several instruments set to operate in the timeframe of CLARREO-PF will obtain data on the Earth's radiation budget that are similar to those that would be collected by CLARREO-PF, which was designed as a 1 year technology demonstration.

AERONAUTICS

NASA's fiscal year 2021 budget requests \$819 million for aeronautics research, managed by the Aeronautics Research Mission Directorate, to support continued U.S. global leadership in aviation technology. The Agency conducts aeronautics research to bring transformational advances in the safety, capacity, and efficiency of the air transportation system and to enable breakthroughs in the speed and efficiency of transport aircraft that are the backbone of today's aviation system as well as innovative new aircraft concepts and technologies that will enable new aviation markets. The fiscal year 2021 request will enable NASA to continue developing and maturing new technologies such as advanced configurations like truss-braced high-aspect-ratio wings, small core turbine engines, high-rate composite manufacturing, and electrified aircraft propulsion that the U.S. aviation industry will use in next generation of subsonic aircraft. NASA is also continuing our investment in critical fundamental technologies for hypersonic flight, including systems analysis, hypersonic propulsion, reusable vehicle technologies, and high-temperature materials.

The budget for aeronautics supports the development of X-planes, including NASA's X-59 Low Boom Flight Demonstrator mission, which will fly a quiet supersonic airplane to demonstrate the community acceptability of low-boom technology. In fiscal year 2021, NASA will prepare the X-59 for first flight, and prepare for community overflight tests and deployment. By 2021, NASA will be flying the X-57 Maxwell aircraft to better inform standards development for smaller, all-electric aircraft.

In fiscal year 2021, NASA expects to complete transition of NextGen airspace management tools and data to the Federal Aviation Administration (FAA) for operational integration. NASA will work with FAA to develop a long-term vision for a transformed National Airspace System based on service-based architectures to enable achieving safe, scalable, routine, high-tempo airspace access for all users.

Future generations will utilize flight in new ways to carry out their day-to-day activities through our exciting vision for Advanced Air Mobility (AAM), building on NASA-developed Unmanned Aircraft System (UAS) Traffic Management and UAS

capabilities. In fiscal year 2021, NASA will lay the groundwork for AAM through research into concepts and technologies for safe AAM operations, and developmental testing for National Campaign events where industry will demonstrate AAM vehicle and airspace management technologies.

OFFICE OF STEM ENGAGEMENT

The functional office at NASA Headquarters will continue to oversee Agency-wide strategic direction and coordination of NASA's STEM engagement efforts. Through Mission Directorate activities, NASA would continue to create unique opportunities for a diverse set of students.

MISSION SUPPORT

NASA must have the enabling technical and professional expertise and facilities necessary to efficiently and effectively support its programs. The fiscal year 2021 request funds capabilities and infrastructure needed to safely operate and maintain NASA Centers and facilities, along with the independent technical authority required to reduce risk to life and program objectives for all NASA missions. To address the significant risk to mission success posed by aging facilities and an increasing maintenance backlog, the 2021 budget includes funding critical to infrastructure renewal and divestment of unneeded, costly facilities. In fiscal year 2021, NASA will strengthen cybersecurity capabilities, safeguarding critical systems and data, while also providing funding to modernize NASA's IT systems.

CONCLUSION

The fiscal year 2021 budget proposed is one of the strongest in NASA history. The reinforced support from the President comes at a critical time as we lay the foundations for landing on the lunar South Pole with the first woman and the next man on Moon by 2024. This budget keeps us firmly on that path.

Senator MORAN. Administrator, thank you.

Let me begin with questions and we will make the rounds of our subcommittee Members who are participating today.

NASA has been challenged with an ambitious goal to return astronauts to the Moon 4 years ahead of what was previously planned. It is an ambitious goal and timelines—they serve a purpose. They can spur motivation, as well as a mechanism to incite decisiveness in decisionmaking.

It is a little over a year since the Vice President's announcement of the accelerated timetable. Concisely can you tell the subcommittee why—and the public—returning to the Moon by 2024 is the right goal and why today is the right time, if that is true?

Mr. BRIDENSTINE. Yes, sir. When we think about the Vision of Space Exploration, there is a lot of history. When we go back to the 1990s, we had the Space Exploration Initiative of the 1990s, and that was a plan to go to the Moon and then on to Mars. The problem was that program took too long, and the longer it takes, the more it costs and the bills add up. It got canceled.

In the early 2000s, we had the Vision for Space Exploration, and that program, of course, again took too long. It cost too much, and it eventually got canceled.

This time we said how do we go to the Moon sustainably in a way that has not been done before, so we can go to the Moon and stay, and not have a program that gets canceled.

Well, we have a lot of benefits today that we did not have even in the 1990s. We have international partners. For example, in November, we are celebrating 20 years of American astronauts and Russian cosmonauts and our European partners and our Japanese partners, our Canadian partners flying, living, and working in space continually for 20 years, which is an amazing accomplish-

ment on the International Space Station. We have international partners today that want to help us accomplish these missions.

We have commercial partners that are driving down costs and increasing access to space, making their own, in many cases, billion dollar investments into these programs.

We really believe that with international partnerships, commercial partnerships, the ability to utilize the resources of the Moon, and moving with alacrity—again, the faster you go, the less it costs. I know that sometimes does not make a lot of sense, but the way budgets work—you know, development programs follow a bell curve. When you try to flatten budgets—when a development program follows a bell curve, it actually takes longer and costs more.

We said, look, we need to compress the timeline. We need to go faster and retire as much risk as possible. That risk, of course, is to cost and to schedule and then bringing in our international and commercial partners, driving down costs, increasing access, and moving with alacrity. I think we have had a lot of success doing that, Mr. Chairman.

Senator MORAN. Let me raise a topic that was raised earlier by Senator Shaheen. In order to achieve our Nation's goals in space, we need a workforce that will rise and meet the future demands. Explain to me the importance of inspiring what I would call the Artemis generation and then NASA's STEM education programs that have been zeroed out for the fiscal year 2021 budget, on the one hand and on the other hand.

Mr. BRIDENSTINE. Yes, sir.

Inspiring the Artemis generation is critically important, and I think there is broad agreement on that. I am the first NASA Administrator in history that was not alive when we had humans living and working on another world. We go back to the cancellation of programs in the past and my generation has this clamoring to actually see people living and working on another world and then taking people on to Mars. The Moon represents that best opportunity to achieve that goal.

Regarding the Office of STEM Engagement at NASA, just so we are absolutely clear, education is critical to what we do, and inspiring that next generation to get involved in STEM is necessary for us to achieve the objectives that we have been given. From that perspective, we are committed to making sure we do that. There are a lot of ways to do that.

Within the Science Mission Directorate, for example, we are very involved in robotics. We call it FIRST Robotics, which is, of course, founded in New Hampshire, for example. We invest about \$4.5 million every year into FIRST Robotics because there is a direct, an absolute direct, return on investment for NASA. If you go out to the Jet Propulsion Laboratory or a lot of the universities that do work for NASA, what you will find is a lot of those folks, the young people, that are doing that work, the brightest minds that we have in this country—a lot of those folks were involved in FIRST Robotics whether in high school or even before. We see a direct return on that.

We think attempting to align as much as possible NASA mission with that education and inspiration effort is the best way to go forward.

It is absolutely true—and I want to be clear about this as well—the Office of STEM Engagement is doing great work, and when we do receive appropriations from the House and the Senate, we move forward on that and they continue to deliver in a great way for the Agency.

It is both. As we go through making budgetary decisions, we look at what is the way to optimize every dollar, and that is how we came to the conclusion we came to. Again, if the Senate appears—you know, sees it a different way, we will follow the law, as we have, and right now OSTEM is doing great work on behalf of the United States of America.

Senator MORAN. Administrator, thank you for your comments, your response to my questions. I think the Senate will see it a different way as we have in previous years.

Senator Shaheen.

Senator SHAHEEN. Well, thank you, Mr. Chairman. I think that is maybe is the case as well.

I would like to applaud NASA's commitment to FIRST Robotics. It has been significant in helping to promote the success of that program. It is nice to hear that the young people who are excited about STEM as the result of FIRST Robotics then take that interest and many of them are involved with NASA later.

Mr. BRIDENSTINE. Yes, ma'am.

Senator SHAHEEN. The Heliophysics Division has been very important in providing data on the inner workings of the Sun and its influence on Earth, including space weather events. Those are valuable not just for their scientific potential but for the direct consequences that they could have on our space exploration efforts, on our ability to safeguard our satellites, on national security assets, on other critical infrastructure.

NASA's progress in these areas' rests on the strength of the Heliophysics Division and the successful implementation of the priorities that have been articulated by the scientific community and the National Academies' decadal survey.

Last year, Congress appropriated \$724.5 million for Heliophysics to continue meeting these recommendations. The administration's request for 2021 would cut funding to Heliophysics by 13 percent. What is the suspected impact of these cuts?

Mr. BRIDENSTINE. A great question. Heliophysics, as you correctly identified, is very important to NASA's missions, as well as national security and even commercial operations in space. It is important that we make sure that we do not fall behind in that area.

Let us see. I think the way to think about this, think about the missions that we have recently launched, even since I have been the NASA Administrator. We had the Parker Solar Orbiter, which was an amazing capability. It has been flying through the corona of the Sun, in other words, through the Sun's atmosphere, if you will.

We just recently this year launched Solar Orbiter, it is a European Space Agency satellite, but it was launched by the United States of America, launched by NASA, which was a huge part of that effort.

We think about the MMS mission which, of course, all of these missions have very important ties to the University of New Hamp-

shire, and I am well aware of the great work that is being done there for NASA's missions. There are others that are important.

I would say this, Senator Shaheen, as those projects have been launched, what happens is the amount of dollars necessary to operate to fund them goes down, and as time goes on—if you look, for example, at the out-years, look at the year 2022, you will see the Heliophysics budget of NASA not just go down, you will see it go right back up. As some projects are coming to a down spending era, we have got other projects that are ramping up. For example, we just recently announced that we are actually going to fly the HERMES mission on the Gateway, which will be an orbit around the Moon, which that drives down the cost for Heliophysics. We are able to do more Heliophysics than ever before. Currently the University of New Hampshire is involved in five other proposals, even right now, that are Heliophysics-centric that are being considered by NASA.

If you look beyond 2021, you will see the budget goes right back up. We do not have any intent to reduce the amount of capability that we are getting from Heliophysics, and I would also say that our goal is to meet the requirements set forth in the decadal survey by the National Academy of Sciences, and I am confident that we are doing that.

Senator SHAHEEN. Well, I have a follow-up question for that, but I am going to go on to another topic and come back to that because NASA has requested \$150 million for low-Earth orbit commercialization activities. I appreciate that it is helpful to be able to think about what kinds of commercialization can yield additional funding that can help NASA do its work.

One of the things that I have to say raised my eyebrows was when NASA announced that it will send up to 10 bottles of Estee Lauder Advanced Night Repair face cream to the International Space Station so that NASA astronauts can shoot videos of the face cream in the microgravity environment.

Now, I am a fan of Estee Lauder's Advanced Night Repair, so like anybody else who might want to benefit from its antigravity properties. However, I guess I am having trouble understanding how Estee Lauder's effort is going to support the commercialization efforts of NASA because, as I understand, they are expected to reimburse NASA about \$128,000, which is a fraction of what the project will cost. NASA has also sent Adidas soccer balls and Boost shoes to the station.

Can you talk about how shooting a cosmetics commercial advances NASA's mission, and what else could we be doing in the time that sending that face cream to space and following up the time that that is taking?

Mr. BRIDENSTINE. Yes, ma'am. I do not think that shooting a cosmetics commercial is the intent of that particular mission, although that might be something that is added to it.

We reserve about 5 percent of the International Space Station really for commercial activities because we do want to have a demand for activities in low-Earth orbit that goes beyond just what NASA does.

Senator SHAHEEN. I get that. Let me interrupt you for a minute.

How was the \$128,000 determined as the cost to Estee Lauder for this project?

Mr. BRIDENSTINE. I would have to take that for the record and get back to you. I do not know the details on that particular issue. I can tell you that as an Agency, you know, for example, we have flown—Nickelodeon has Slime, for example. We have flown Slime to the International Space Station. We have used the International Space Station to actually brew beer, for example. These are all specifically selected for scientific purposes, but they also have commercial opportunities as well. Again, we reserve about 5 percent of the International Space Station for those activities.

Senator SHAHEEN. For something like the face cream, are there any provisions that would say if that is the work that was done on the International Space Station is then used in a commercial that NASA would get some percentage of those costs, or are they prohibited from using the information in an ad? It seems to me that using our tax dollars in that way to support a private company to benefit from the dollars of research is something that we ought to think about.

Mr. BRIDENSTINE. Yes, ma'am. I do not know the details on the Estee Lauder mission, for example. I could certainly ask those questions, and I can get something back to you. I do not know the details on how it was selected, whether it went through the ISS National Laboratory or it might have gone through the Johnson Space Center specifically. I am just not sure about that particular mission, but I will look into it and get you the details.

Senator SHAHEEN. Thank you. As I said, I am not aiming that necessarily at Estee Lauder but just in general, how are we choosing the projects that we are looking at commercializing the low-Earth orbit activities. Is there a bidding process? How is the cost determined? The details around how this is being done.

Mr. BRIDENSTINE. Yes, ma'am. I can tell you that everything goes through a very competitively selected process and that scientists are the ones that are making these decisions. I will get back to you with those details.

[The information follows:]

COMMERCIALIZING THE LOW-EARTH ORBIT ACTIVITIES BIDDING PROCESS AND HOW COST IS DETERMINED

Future operations in low Earth orbit (LEO), whether on the ISS or future platforms, will be more affordable if they can regularly attract customers other than NASA. Because a robust commercial market using LEO space platforms does not yet exist, NASA has been working to enable and stimulate commercial activity on the ISS. In June 2019, NASA announced plans to expand the scope of activities that could be performed on the ISS, to include commercial business opportunities. Up to 5 percent of NASA's utilization resources were allocated to U.S. entities to conduct commercial activities. Details associated with this policy, along with pass/fail criteria, were documented in the NASA Interim Directive (NID) 8600-121, "*Use of International Space Station (ISS) for Commercial and Marketing Activities*" and are summarized below:

1. Evidence that the entity requesting resources meets the criteria of a U.S. entity
2. Compliance with one or more of the following:
 - Require the unique microgravity environment; or
 - Have a nexus to NASA's missions; or
 - Supports a sustainable LEO economy.
3. Conformance with NASA Interim Directive governing commercial activities on the ISS

4. Reasonableness of the amount of resources requested

Proposals were received under the NASA Research Announcement (NRA) NNJ13ZBG001N, Focus Area 3, and reviewed by the Commercial LEO Panel (CLP) to determine if the proposals met the criteria listed above and were consistent with NASA's other policies and regulations. The CLP is a management forum delegated by the Human Exploration and Operations Mission Directorate (HEOMD) with the express purpose to enable, evaluate, and implement Commercial LEO projects, economic development, and competitive strategy policies and agreements with the goal of enabling a robust LEO economy and commercial LEO destinations by the end of life. The CLP serves as a working forum to coordinate with Commercial LEO stakeholders across NASA. The Commercial LEO Development Program Manager serves as the chair and the panel membership includes the ISS Program, various technical authorities at the Johnson Space Center (JSC) such as the Flight Operations Directorate (FOD) and Engineering, and a number of NASA Headquarters Offices such as Procurement, General Counsel, Safety, and Communications. There are also ad hoc members that participate when topics require their expertise, such as the Federal Aviation Administration (FAA) and Commercial Crew Program (CCP). Panel members evaluate proposals and provide recommendations to HEOMD for approval and implementation.

As part of the NASA Interim Directive 8600-121, NASA developed a pricing policy that subsidized the overall value of the indirect costs associated with cargo and crew time to support these activities. The pricing policy posted in June 2019 included an 85 percent subsidy. In late 2020, based on industry comments and future capability to purchase similar services from a Private Astronaut Mission, NASA began formulating an update to the pricing policy to decrease the subsidy to 50 percent in January 2021, with plans to move to a 0 percent subsidy after the first Private Astronaut Mission demonstration flight.

Senator SHAHEEN. Thank you.

Thank you, Mr. Chairman.

Senator MORAN. Senator Manchin.

Senator MANCHIN. Thank you, Mr. Chairman.

Thank you, Mr. Bridenstine, for being here.

While many of us here today have focused on the Artemis program and our return to the Moon, I would like to go back a little bit further and talk about the Apollo program, our first mission to the Moon.

Every NASA mission relies on a team of scientists, engineers, and others to design, manufacture, and verify that these spacecrafts can, indeed, reach their intended target. You cannot just point a rocket into the sky and light a fuse. You have to verify that your trajectory reaches your destination and validate through complex calculations that will work.

In the 1960s, those were done by hand, and for our most important flights, it was Katherine Johnson, a West Virginia native, that did those. Today we use software to make those calculations. NASA Independent Verification and Validation (IV&V) Facility in Fairmont, West Virginia bears her name and proudly carries on the tradition by ensuring the software is safe, reliable, and can be trusted to ensure our missions are completed and get home safely.

Now, I am pleased that you have committed to utilizing IV&V for our return to the Moon. However, this is an incredibly complex, expensive mission, and yet IV&V's total budget is just \$39 million for next year. Just like its namesake, Katherine Johnson once validated IBM's work on the Apollo program, it is critical that IV&V has the funding to maintain its independent analysis of these programs.

Can you commit to providing the funding and workforce necessary for the IV&V to do the critical job and ensure that we return safely to the Moon?

Mr. BRIDENSTINE. Yes, sir. The Katherine Johnson IV&V facility in West Virginia is absolutely critically important to NASA's mission, and it is necessary to keep our astronauts safe.

Senator MANCHIN. The budget process. Do you feel confident you will have the necessary budget to do it?

Mr. BRIDENSTINE. Yes, sir, I do. I think the IV&V facility is well resourced now, and of course, the budget request that we have before the House and the Senate I think is a strong budget request for the requirements that we have for the Orion crew capsule, for example.

Senator MANCHIN. Do you remember that? What is that amount that you are asking for there?

Mr. BRIDENSTINE. You said it was in the \$39 million range.

Senator MANCHIN. \$39.1 million.

Mr. BRIDENSTINE. \$39.1 million.

Senator MANCHIN. Just down the road from the Katherine Johnson IV&V facility, the West Virginia Robotics Technology Center has been the lead academic partner for NASA's Restore-L satellite servicing mission since 2009. Last year, NASA made a decision to combine the Restore-L satellite servicing mission with a Space Infrastructure Dexterous Robot, SPIDER, which will demonstrate manufacturing assembly of a communications antenna in space. Both of these programs will be launched On-Orbit Servicing, Assembly and Manufacturing OSAM-1, spacecraft. I applaud NASA and its industrial partners like Maxar for thinking outside the box to achieve cost savings and ensure these critical programs move forward. NASA's goal of returning to the Moon and beyond will require the continued development of robotics technology like this and a workforce to support these endeavors.

Can you tell me how that program is progressing?

Mr. BRIDENSTINE. Yes, sir. The OSAM-1 mission—a number of the instruments and robotics have gone through critical design review. Others are still in front of us, but that overall mission is progressing very well. We are very grateful to the West Virginia Robotic Institute. We are also very grateful to the Goddard Space Flight Center for the great work being done on the OSAM-1 mission.

I will tell you that our goal as an agency is to not only be able to do this as a technology demonstrator, but we see a day in the future where satellites in low-Earth orbit and even geostationary orbit eventually can not only be serviced but maintained, so refueled and, of course, maintenance can robotically. That future of course—right now, it is NASA developing the capabilities and the technologies.

The future that we see is that those technologies will be commercialized, and we can see a day in the future where there would be dozens of satellites in low-Earth orbit operated by numerous companies a the profit motive ultimately to service and do maintenance on satellites in orbit, which would be a huge cost benefit to satellite operators and even prevent orbital debris from—you know, when these satellites come to the end of their lives, they become orbital debris in many cases.

Senator MANCHIN. Your current budget of \$227 million—is that going to be sufficient to launch on track for 2023?

Mr. BRIDENSTINE. I believe it is, sir. We are committed to that mission, as you know.

Senator MANCHIN. Thank you, Mr. Chairman.

Senator MORAN. Senator Van Hollen.

Senator VAN HOLLEN. Thank you, Mr. Chairman, and I thank the Ranking Member—I know she had to leave—as well. And to Administrator Bridenstine, it is great to see you again.

Mr. BRIDENSTINE. Always.

Senator VAN HOLLEN. This hearing is obviously an opportunity to compare notes on priorities. As you know—and thank you for mentioning NASA Goddard. We are proud to have them in the State of Maryland, along with the Wallops Flight Facility, which of course straddles the Virginia/Maryland line, as well as Johns Hopkins-APL, the Hubble Space Telescope and other things. We consider ourselves a very active State when it comes to space exploration and the Earth sciences. Obviously, also home to NOAA.

In the last couple years, I pointed out what you know, which is that you are not ultimately responsible for the budget that comes to us from the Office of Management and Budget, but I want to reaffirm with you the merits of some of the programs and then with the Chairman and the Ranking Member of this subcommittee, we will make decisions with respect to our priorities.

In the last 2 years when you have come before the subcommittee for this hearing, I have asked you about the importance you place with respect to the guidance of the decadal survey.

Mr. BRIDENSTINE. Yes, sir.

Senator VAN HOLLEN. As you have said in the past, it is very important that NASA be guided by the recommendations of that decadal survey. That is what you said for the last 2 years. I want to confirm that that remains the case. Does it?

Mr. BRIDENSTINE. Absolutely, 100 percent.

Senator VAN HOLLEN. One of the programs—in fact, the program that was ranked number one by the 2010 decadal survey with respect to astronomy and astrophysics, was the WFIRST program, recently renamed the Roman Telescope. It had the highest scientific priority space astrophysics mission rating.

Mr. Administrator, would you agree that that remains an important priority for our country?

Mr. BRIDENSTINE. I do.

Senator VAN HOLLEN. Thank you.

I know because you and I have talked about so many of the important aspects of NASA, but would you agree that if we do not move forward with this mission, it will lead to long-term costs for the project in the future?

Mr. BRIDENSTINE. It absolutely will. The longer a program goes, the more it costs.

Senator VAN HOLLEN. We would lose important knowledge of the decadal survey to prioritize our understanding. Is that right?

Mr. BRIDENSTINE. I think that is true. I would also add just as a point of reflection, that the WFIRST is really a complement to the James Webb Space Telescope. Obviously, we have had some delays with the James Webb Space Telescope although we now have that on track for an October launch of next year, and that is moving along very well even in the midst of the COVID-19 crisis.

I do believe the WFIRST is important to the Nation. I believe it is a mission that is obviously not just important in my view but also the National Academies who put together the decadal survey. Yes, we are committed to that mission, and it has been appropriated, we are building it right now. In fact, we are past Critical Design Review. In fact, I think it was February of this year we did the Critical Design Review, and now it is, in fact, being built.

Senator VAN HOLLEN. I appreciate that. As I am sure you know, GAO came out with its assessments of major projects and talked about the progress being made.

Mr. BRIDENSTINE. Yes.

Senator VAN HOLLEN. We compliment you on those advances.

The PACE program and CLARREO programs have also been mentioned and referred to in the decadal surveys, and I just want to reaffirm with you now the importance of those projects to our scientific endeavor.

Mr. BRIDENSTINE. Yes. Both of those are important to understanding oceans. It helps us understand how our climate is changing, and that is what PACE is all about. CLARREO Pathfinder—that is basically a radiation instrument, so we know how much energy is coming from the Sun and how much is being absorbed by the Earth compared to how much is being reflected back out to space. That is a mission that is going to really help us understand the climate change that we are seeing. Both of those missions are important to our understanding of the Earth, which is why they were a high priority in the decadal survey.

Senator VAN HOLLEN. Got it.

Finally—and you discussed this a little bit with Senator Manchin and may have with other Members. The Restore-L program I know you see as essential robotics servicing capability as we go forward. Again, you have a 100 percent commitment to go forward with that. Is that right?

Mr. BRIDENSTINE. We are, in fact, going forward very rapidly with that. The first mission we are going to service a Landsat 7 satellite, which is operated by USGS, and then we are going to move forward from there. All of those technologies are hugely important for the Nation because ultimately if we can service satellites in orbit, it drives down costs, it enables us to do more than we could otherwise do, and at the same time, it prevents the orbital debris challenges that we are seeing.

A lot of people saw even last night, we had to maneuver the International Space Station. That is the third time in 2020 we have had to maneuver the International Space Station, and the last time we had to maneuver it was 2015. The orbital debris problem is getting worse, and I think OSAM-1 is going to be very helpful in mitigating that challenge.

Senator VAN HOLLEN. I appreciate it. I have some additional questions for the record, but that is all for now. Thank you again.

Mr. BRIDENSTINE. Yes, sir.

Senator VAN HOLLEN. Thank you, Mr. Chairman.

Senator MORAN. Thank you, Senator Van Hollen.

Mr. Administrator, let us reassure me or highlight for me the challenges you face, NASA faces, in meeting that 2024 mission to the Moon. What are the benchmarks that you need to see accom-

plished today—or let me start earlier. In the past, what are the checkmarks that say we have accomplished this? It allows us to proceed and we are on track. What are the benchmarks we should be watching to see if you are able to meet that would give greater assurance that 2024 is a realistic option?

Mr. BRIDENSTINE. That is a great question.

Right now, we are doing the Green Run tests on the SLS rocket, which is the only rocket that has any chance of being able to take our astronauts to the Moon by 2024. That Green Run test—we have completed five of the eight tests. In November, we intend to actually fire the rocket engines, all four RS25 rocket engines, at the same time for the Green Run test down at the Stennis Space Center. That is a big, big milestone. Once that is accomplished, that rocket is going to be moved to the Kennedy Space Center to be assembled with the solid rocket boosters, which have already been delivered, and with the Orion crew capsule and the European Service Module, it will be stacked down at Kennedy for a launch in November of 2021.

Meeting the Green Run tests and then a launch in November of 2021 for Artemis-I, which is uncrewed, orbit around the Moon—those I think are key milestones. That is on the rocket side.

Now, if we are able to achieve that, we will be on track for Artemis-II in 2023. If that Artemis-I mission pushes too far from the end of 2021, it starts to encroach on Artemis-II, which would happen in 2023. Then it creates a crescendo where once one starts getting pushed, the others start getting pushed. We got to make sure that we stay on track there.

I would also say the other big challenge for us is the Human Landing System. Now, I would say this is the biggest risk because this is a brand new Human Landing System. We have not built a Human Landing System since 1972, and now we are doing it again for the first time. Right now, we have a Human Landing System funded for the first time since 1972. That has not happened since 1972. It has not happened in my lifetime, which puts it in perspective, and I am 45 years old.

I think getting that Human Landing System funded was a huge step. We got that last year. We are currently funded at \$600 million. The House Appropriations Committee passed their own appropriation bill that had \$600 million for that human landing system, which we are very grateful for, and that is for 2021. We are grateful for that. I want to be clear.

I will also tell you that that is not enough to achieve the 2024 Moon landing. I am glad that they did it. It shows strong bipartisan support that we all agree we need to go to the Moon. Again, the longer the program goes, the more I worry that it becomes at risk. Accelerating it to 2024 requires a \$3.2 billion budget for 2021 for the Human Landing System, which is in the President's budget request. Anything this subcommittee can do to help us get those resources is critically important.

Now, I will also say that even right now, as we go through this first period with the Human Landing System, we have three companies under contract. Again, that is a good milestone, and they are all meeting their objective, which is we want to be able to—in this first phase, we want to be able to, by February of next year,

declare which of the three we are going to go forward with. Depending on what they come back with as far as their proposals, we might select two. We might even keep three in the game. It just depends on what they come back with. We are anxiously anticipating how the companies propose what their solution set is to get to the Moon, but we are doing this differently than we have ever done it before. We are doing it commercially. We are giving them a lot of leeway. We are not being prescriptive. We are giving them freedom to create solutions that are going to be in their interests that go even beyond NASA, so for commercial activities, for example, on the surface of the Moon.

I guess the big thing is the SLS rocket needs to be complete and then the Human Landing System. We have got to get it funded and then we got to make sure we are meeting our milestones, but as of right now, we are meeting all the milestones necessary to achieve a 2024 Moon landing.

Senator MORAN. Would you attach dates or years to—would you attach points in time to those two events? By when do each need to happen?

Mr. BRIDENSTINE. Yes. As an Agency, we need to select the Human Landing System by February of 2021, and again, depending on what their proposals are, their proposals will have milestones that we will be able to measure them against, and we will be tracking those very, very diligently and even providing our own feedback as to what we think those milestones should be as well. It is a true public-private partnership. We will be looking for those milestones come February of next year on the human landing system.

As far as the SLS rocket, by November of 2021, we need to have Artemis-I launched and then we need to be prepared for Artemis-II by 2023. Those are the two big milestones.

Senator MORAN. For this mission to be successful to meet its goal of 2024, does NASA have the personnel and the leadership now in place? There have been some changes at NASA in the last year. The leadership now in place you would expect to be able to meet the goals?

Mr. BRIDENSTINE. Yes, sir. I will tell you Kathy Lueders is now the head of Human Exploration and Operations. That is the Mission Directorate responsible for getting our first woman and next man to the south pole of the Moon by 2024. She has run two very successful programs, the first one being Commercial Resupply of the International Space Station and now Commercial Crew of the International Space Station, and because of her monumental efforts and achievement, we have placed her in charge of the entire Mission Directorate to achieve this objective.

Senator MORAN. Administrator, you said something that caught my attention about the potential. We have three teams that are competing for the landers, really for the business to utilize their plan, their equipment to land on the Moon. The competition is still ongoing. I understand that. The way I understood it was that the three would be narrowed to two and ultimately narrowed to one. You indicated you might keep the three in longer, if I understood you correctly.

Is there any thought that you can go from three to one and skip the second expense of two in competition?

Mr. BRIDENSTINE. Yes, sir. There are discussions about this. What we need to see is at the end of this what we call the base period, which ends in February of 2021, we need to look at how robust their proposals are and what they are suggesting in terms of dollars. Some of these providers are investing a lot of their own money. We really do not know what they are going to necessarily put forward for NASA to fund and what they are going to do in a public-private partnership. It is premature to say, sir, I think at this point whether it is going to be three or two or one.

I will tell you—and this is a concern to me—I worry about going down to one, and I will tell you why. When you eliminate the competition, you end up with programs that inevitably get dragged out and you end up with cost overruns and schedule delays. I can give you lots of—I am not going to dime anybody out right now, but I can give you lots of examples where that is the case, both at NASA, the Department of Defense, and other places.

If we are going to the Moon commercially and we keep two providers in the mix, what happens is there ends up being this virtuous cycle where they are making their own investments, they are committing their own resources to achieve the goal that is the goal of the United States of America. I think that is a positive development that is good for the American taxpayer. We have seen the success of that with the Commercial Crew Program, which was a fraction of the cost of the Space Shuttle program, for example.

Senator MORAN. Is an uncrewed flight demonstration a requirement before sending a crew to the Moon?

Mr. BRIDENSTINE. It is not necessarily a requirement, but of course, when NASA evaluates proposals, we will be looking for what are they doing to retire risk and the processes and procedures that they have. I do not want to say what is in the proposals or anything, but there is a lot of interest. I will just say that. There is a lot of interest in making sure that there is a precursor mission that is uncrewed.

Senator MORAN. There have been, over the history of NASA, lots of mission delays. We have seen GAO reports that are regularly published on NASA's projects that show major delays in missions across the Agency.

What is NASA doing now to reduce the likelihood of that being an occurrence during the Artemis program?

Mr. BRIDENSTINE. Right now, I mean, if you look at how NASA is dealing with COVID-19, we have prioritized missions based on whether they are mission-essential or mission-critical. Mission-essential functions are high priority for the Nation, and those functions have been going forward. We saw that with Commercial Crew. We saw that with Mars Perseverance, and of course, we are seeing that with the Green Run test right now on the SLS rocket.

It is also true that in any program that NASA does, we always make sure that we have reserves, the reserves being both in schedule and cost, because when we do things, we do things for the first time ever, and we always learn what we do not know in the process of development and then testing.

We do have reserves. I will tell you with COVID-19, those reserves on all of our programs are being eaten up because people just do not have access to facilities. We have suppliers that are not going to work. We have suppliers that are very strained financially. These things have an effect. As of right now, I will tell you the reserves are being eaten up rapidly for pretty much all of our programs.

On the Artemis program, most of that work is mission-essential, and so it has continued to go forward. We are making sure that everybody has their personal protective equipment that we are keeping social distancing, we are keeping our people safe. We have also said that if people do not feel safe going to work, they ought not go to work. Everybody's circumstances are different. People have different medical conditions, different conditions at home. People have mother-in-laws that live with them, for example. I say that because I have a mother-in-law that lives with me, and she has got Multiple Sclerosis, for example. She is not somebody that we can risk getting COVID-19. Different families have different circumstances. We want to make sure we get the right people on the right projects, people that we can protect by having them not involved in the project we protect. We have been very successful in keeping our people safe on these mission-essential functions, and we will continue to do that for the Artemis program.

Senator MORAN. Let me run through a couple of items somewhat quickly, but they are important.

What should Americans know the value to them of going to Moon, returning to the Moon? Let me start by saying what scientific advancements related to the Moon would you see occurring as a result of being back on the Moon?

Mr. BRIDENSTINE. Oh, there is so much.

First of all, we discovered in 2009 that there are hundreds of millions of tons of water ice on the south pole of the Moon and a lot on the north pole of the Moon as well. There are things happening at the Moon that we do not understand. You know, a couple of weeks ago, we discovered rust on the Moon which means there is oxygen there, if you can imagine that. Now we are doing scientific experiments to understand how the oxygen is getting to the Moon because it is not being originated at the Moon. Maybe it is coming from the Earth. Now we are learning new things about whether or not oxygen from the Earth is actually getting to the Moon. Those are little things.

When we think about Heliophysics, for example, the study of the Sun, the Moon represents a body in space that does not have an atmosphere. It does not have a hydrosphere. It does not have an active geology. Anything that impacted the Moon billions of years ago is today right where it was billions of years ago. That includes subatomic charged particles that have been coming from the Sun. It includes asteroids from deep space. Of course, we see all of the pock marks on the Moon. Those pock marks are there specifically because it does not have an atmosphere that eats up those asteroids when they come in contact with the Moon. Our atmosphere eats them up, and when they do hit the Earth, the Earth, because of its active geology, it chews them up. We have an active hydrosphere. When we find those metals—we call them rare Earth met-

als—they are very trace. There could be large deposits on the Moon that would give us a lot of knowledge and information about our own solar system.

I would also say imagine an orbiter around the Moon that cannot only see the first light in the universe after the Big Bang, but could actually see back into the Cosmic Dark Ages, after the Big Bang and before first light occurs. From the far side of the Moon, it is so quiet from an electromagnetic spectrum perspective that we are going to be able to see and make assessments as to the physics of the early universe, which of course is going to transform how we think about energy, for example. These are missions that I think are critically important for science.

On the far side of the Moon, we can put very simple wire antennas that will pick up very low frequency signals that—you know, back in the early universe, those very low frequency signals would have been light. As the universe has expanded, those waves have expanded as well, and now we can pick them up as radio frequencies. Again, we can see and make assessments as to the early universe.

Also on the Moon, we could put optics. We could actually detect from the Moon planets orbiting other stars in a way that we cannot do from the Earth and we cannot do it from a free-flying satellite. We can do it from the Moon because it is so stable. Imagine having the most stable satellite in the history of satellites ever. Well, it is a natural satellite. It is called the Moon. We can put optics on the Moon and see tiny little flickers of a star that are routine and make assessments as to whether or not that is a planet.

Once we know that there are planets around these other stars, which at this point we have discovered something like 9,000 planets around other stars, and all of these are new discoveries. Now we are going to have the James Webb Space Telescope. We can train it on those planets specifically. We can see the light coming from those stars through the atmospheres of those planets, and we can make assessments as to whether or not those planets have life.

We could even make assessments as to whether or not those planets have industrialized life, if you can imagine that. I am not suggesting that that exists. I do not have any idea. But it is just fascinating to think about we are going to be able to see those things, and the Moon is a critical piece of that.

It is about Heliophysics, the study of the Sun, because the regolith represents those impacts of subatomic charged particles. It is about astrophysics, the study of deep space. It is about planetary science because when we go to the Moon, we are learning how to live and work on another world so that we can go to Mars. Of course, it is about Earth science. We are making new discoveries all the time.

Dr. Thomas Zurbuchen, who runs the Science Mission Directorate at NASA, ordered the opening of Apollo samples that we have had preserved now in a vacuum for 50 years. He wanted to open those samples because now we have new technology to assess those samples. From that assessment, we are able to see how the Earth and the Moon formed. Did we form together and then separate? Did we form separately? Now we are understanding that in fact we actually were, obviously, part of the same system, and we

were formed about the same time. These are fascinating discoveries. It is because of the Moon.

Now when we go to the Moon, unlike the 1960s and 1970s, we have so much more technology that we can apply to what we discover. It is going to revolutionize our understanding of the universe.

Senator MORAN. Administrator, I was trying to decide whether I needed to cut you off.

Mr. BRIDENSTINE. Sure.

Senator MORAN. No, based upon your enthusiasm and the long list of things that can be accomplished scientifically with a visit to the Moon.

What can I tell universities in my State that they might be able to do to participate in this mission?

Mr. BRIDENSTINE. We love it when universities get involved in these missions for a number of reasons. When a university, for example, puts together a science instrument, the researcher, the scientist, for example, and the engineer are together, and they make trades early in the process. When we give them a schedule and a budget, the scientist and the engineer get to work. When the engineer says, you know, hey, this is going to cost this much. What if we did this? They are sitting there with the scientist and the scientist can make determination quickly as to whether or not the new solution is going to work for the science that they are trying to achieve. It helps us as an Agency keep projects on budget and on schedule, and it works like magic.

Even better with the university, we get the students involved, and those students, whether they are graduate students, undergraduate students—they get hands-on experience. They graduate not just with chemistry, calculus, and physics, but they are graduating with hands-on experience building satellites and robots for NASA so that they can get to work right away in the workforce.

I would say if we look at in the next—as we look at going to the Moon specifically, we are going to have missions on every single one of those Artemis missions. Some of those missions are going to be cubesats that are going to maybe remain in orbit around the Moon. Some of them might go off into deep space. That is for Artemis-I, II, and III. Universities can maybe participate there and make proposals on Artemis-II and III, for example, in the new future. Artemis-I—we have got 13 satellites already committed with universities from across the country.

We think about when we go for Artemis-I, when we land on the surface of the Moon. We are going to have science on the surface of the Moon for the first time since 1972. There are opportunities there.

The Gateway. Tremendous opportunity for science. We just recently announced that we are going to have the HERMES mission on the Gateway, which is a Heliophysics capability. That HERMES mission has a lot of researchers from universities across the country.

The best thing for a university to do is go to the NASA website and look for solicitations, and then make proposals for this particular project.

I will also tell you—and you know this, Senator—Wichita State University is critically important to NASA’s mission. That is true in aeronautics.

The aeronautics industry right now has been devastated. We have had the Max-8 issue. We have now had the COVID-19 issue. We need to be making the investment into the aeronautics industry in a way that makes sure that when we come out of COVID-19, we remain the world’s leader in exports in aeronautics. That means we need to have the resources for new designs of aircraft, a truss-braced wing for higher aspect ratio wings, for example, to get us more efficient aerodynamics. We need smaller core engines to get higher bypass and more fuel efficiency. We need advanced composites, high rate composites. There is no place better than Wichita to work on high rate composite manufacturing, and we have had a number of partnerships with Wichita State University. Now we are starting a new high rate composite program, and I would imagine Wichita State University is going to be part of that consortium yet again.

I think there is no shortage of opportunities for universities. We love their involvement. We need their involvement. Of course, the best thing to do is figure out what are the niche areas that the university has competencies and then how do we apply those to NASA’s missions, and let us get them involved.

Senator MORAN. Thank you for that answer.

You did participate in a panel with academia and industry at Wichita State last summer, and I very much appreciate that. One of the things that that panel was charged with discussing is how interconnected national security and space have become, and anything we should know about the capabilities or the enhancement of our national wellbeing, our national security wellbeing that comes from space, particularly the Artemis program.

Mr. BRIDENSTINE. Absolutely. A couple of things that are important to note.

Number one, the United States of America has amazing international partners. When we think about the tools of national power, in the military we talk about DIME, diplomatic power, information power, military power, and economic power. NASA plays on the diplomatic side very strongly. Fifteen partners on the International Space Station. Astronauts from 19 different countries have flown on the International Space Station. Experiments from 103 different countries. We currently have over 700 active agreements with countries all around the world for experiments not just on the International Space Station but into deep space with science and other capabilities. It is a tool of diplomacy.

As far as a tool of information power, there is going to come a day when humans land on the Moon again. That day is going to happen. The question is, will it be the United States of America leading a coalition of international partners or will it be somebody else? In my view, it ought to be the United States of America that leads that coalition.

We think back to the Apollo era when Neil Armstrong and Buzz Aldrin walked on the Moon. Everybody on the planet saw it, and it was a magnificent moment to demonstrate America’s political and economic system was superior to that of the Soviet Union at

the time. Those tools of information power and demonstrating the strength of the United States of America are very strong.

Of course, on the economic side, we are constantly building the American economy and all of our activities on the International Space Station and commercial efforts have demonstrated. For example, we had 0 percent of the commercial launch market in 2012. Zero. Today we have got over 70 percent, and it is because of investments made by NASA into our commercial resupply and commercial crew partners. That percentage is going to grow as time goes on.

I think we play in all of these spheres of national power. We are not a military organization, but diplomacy, information, and economic power—we play very strongly there.

Senator MORAN. Administrator, thank you. It is a good thing you did speak so long, otherwise we would not be able to hear the questions from Senator Boozman. We would have concluded before he arrived.

Senator BOOZMAN. Thank you, and I apologize for being late.

Here I am in Senator Shelby's place.

Senator MORAN. Of course, you wish you were.

Senator BOOZMAN. Exactly.

But anyway, we appreciate you. Thanks for all the great work that you do. Again, those of you that work with you, your organization is something that our country is very, very proud of and has been for many, many years. You have adhered to that great tradition and moving us forward.

Again, I apologize for being late, but I am going to ask you about something that has probably already been mentioned but it really is important.

Arkansas' Space Grant Consortium continues to lead the way on educating undergraduate and graduate students on aerospace fundamentals, research, opportunities offered by NASA, the aerospace industry, and the list goes on and on.

Additionally, they familiarize and motivate K through 12 students with STEM-related courses. This has been a huge thing that Governor Hutchinson is doing and doing in a very, very good way so that we can get people into aerospace programs and related industry. With critical funding from NASA, this association produces the next generation of scientists and engineers, educators, astronauts that the country needs to continue to keep us ahead of the rest of the world.

Once again, this year's budget request proposes eliminating NASA's Office of STEM Engagement and the Space Grant, EPSCoR, and other programs. This would put an end to organizations like Arkansas' Space Grant Consortium, which would hurt educators and students from all walks of life who have a passion for space and strive to one day work in the aerospace industry and for NASA.

I guess in your testimony on this issue, it was kind of a little bit brief, a little bit vague on how NASA would continue to create opportunities for those students. Additionally, in the fiscal year 2021 budget, it mentions that NASA will continue to support internships, fellowships, and the administration's STEM priorities but does not say how that is going to be represented.

I guess my question is, how will your agency continue to support and fund programs like Arkansas' Space Consortium and students without the Office of STEM Engagement and its funding? You know, I have had the opportunity to get to know you through the years with your service in the House and now again working with you with the great job you are doing. Being from Oklahoma, you know, very similar States, very similar challenges. Tell us exactly how that is going to work.

Mr. BRIDENSTINE. Yes, sir. A couple of things.

Number one, the Office of STEM Engagement at NASA is doing amazing work. I can say that with a very clear conscience. I can also tell you that a lot of that work, EPSCoR and other contracts—I have seen the fruits of that work at the University of Arkansas, Fayetteville, for example. I was just there not too long ago, and they have this amazing capability at the University of Arkansas to replicate the atmospheres of planets, which is fascinating. Of course, that is, of course, because NASA has made investments through EPSCoR and other processes.

It was great talking to the researchers there because they are students. They are the students that are actually benefiting from this laboratory where they replicate the atmospheres of other planets and then determine what could we do on that planet when we land there. I think it really is great work there at the University of Arkansas.

I will also say the way we see it is we want to align the mission directorates specifically to—I should say the missions that NASA has specifically to the educational initiatives. If we can do that, I think it would be even more beneficial. I gave an example earlier about FIRST Robotics, which is an amazing capability where young people get involved in building robots for competitions. NASA, through the Science Mission Directorate, funds that to the tune of about \$4.5 million every year.

The reason the Science Mission Directorate does that is because they need people that can build robots, and if you go to the Jet Propulsion Laboratory out in Pasadena, California or other NASA centers where they are involved in robotics, you will often find those engineers were involved in FIRST Robotics when they were in high school or even before. There are ways for us to invest in that education STEM effort that are not necessarily from the Office of STEM Engagement.

I can tell you this. If the Senate appropriates and the House appropriates those resources, we will continue to use them as we have, and they do provide fruits that are very valuable to the Agency.

With that, I will leave it there. We are committed to STEM engagement.

Senator BOOZMAN. We appreciate that. Again, I know it has been discussed. Anytime anyone is around you from the subcommittee, it is going to be discussed at length. We appreciate you going over it again.

Very quickly, with your permission, Mr. Chairman—

Senator MORAN. [inaudible.]

Senator BOOZMAN. Right. I will take advantage of that then.

Tell us. You know, we have asked you a lot of questions and shared our concerns. What is your concern with the agency? What do we need to be doing to help you? I know you have got your budget and things like that. Not necessarily certainly from a money standpoint, but also just how can we provide the support that you need to continue supporting this great agency that I think I can speak for all of us we are very, very proud of?

Mr. BRIDENSTINE. Yes, sir. I will tell you one thing that has me very concerned and that is that a day is coming when the International Space Station comes to the end of its useful life. In order to be able to have the United States of America have a presence in low-Earth orbit, we have to be prepared for what comes next.

We have requested in the budget requests \$150 million for low-Earth orbit commercialization. We have built commercial resupply to resupply the International Space Station where we buy a service from commercial companies. Those commercial companies go get customers that are not NASA and that drives down our costs. We have done that with a commercial crew now which has now been successful.

The next big thing is we want to see a public-private partnership where NASA can team with commercial Space Station providers so that we can keep a permanent, uninterrupted human presence in low-Earth orbit. I do not think it is in the interest of the Nation to build another International Space Station. I do think it is in the interest of the Nation to support commercial industry where NASA is a customer as we can then stay in low-Earth orbit and then go on to the Moon with the resources that we need to get to the Moon.

I do have a concern. China is rapidly building what they call the Chinese International Space Station, and they are rapidly marketing that space station to all of our international partners that we as a nation have invested in to build their capacities for space flight. I think it would be a tragedy if, after all of this time and all of this effort, we were to abandon low-Earth orbit and cede that territory.

The value of the low-Earth orbit is microgravity where we can compound pharmaceuticals and create immunizations for salmonella and pneumonia and other things. We can print human organs in 3D. We are proving that we can do that right now. You cannot do that on the Earth. We can create artificial retinas for the human eyeball so people with macular degeneration do not have to lose their eyesight.

All of these are commercial efforts that are tremendously valuable to the future, but without NASA as a partner, commercial companies are not going to invest. We need to do those public-private partnerships to have commercial low-Earth orbit, which will drive down our costs, and we can be a customer there, and then ultimately not cede that territory to another country that does not have our interests at heart.

Senator BOOZMAN. Very good.

Thank you, Mr. Chairman. Thank you.

Mr. BRIDENSTINE. Yes, sir.

Senator MORAN. Senator Boozman, thank you.

Administrator, anything that you would like to add, augment, correct?

Mr. BRIDENSTINE. Yes. I was corrected on one thing that I said earlier. I think Senator Moran asked me if Restore-L would be ready to launch in 2023, and I responded, yes, I believe so. I was just corrected. It is scheduled to launch in 2025. I wanted to make sure that that was clarified.

Senator MORAN. Administrator, thank you. Anything else?

Mr. BRIDENSTINE. Oh, Senator Manchin. I am sorry.

Senator MORAN. I knew the right name.

ADDITIONAL COMMITTEE QUESTIONS

If there are no further questions this afternoon, Senators may submit additional questions for the subcommittee's official hearing record. We would request that NASA respond to those questions within 30 days.

[The following questions were not asked at the hearing, but were submitted to the Agency for response subsequent to the hearing:]

QUESTIONS SUBMITTED TO HON. JAMES BRIDENSTINE

QUESTIONS SUBMITTED BY SENATOR LISA MURKOWSKI

REVIEW OF THE FISCAL YEAR 2021 BUDGET REQUEST FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Question 1. The U.S. Federal Government and State of Alaska have jointly invested over \$100 million in capital improvements at the Pacific Spaceport Complex—Alaska (PSCA), formally known as the Kodiak Launch Complex, on Kodiak Island, Alaska. As one of only two U.S.-based spaceports that can launch into high-inclination and polar orbits, PSCA is positioned to ensure the United States maintains leadership in space. This FAA-licensed commercial spaceport is a low-cost operation, capable of launching solid- and liquid-fueled rockets and has supported numerous government orbital, suborbital, and test missions since 1998. However, NASA has only used PSCA once, in 2001, for the Kodiak Star mission which, along with the other Starshine satellites, was inspirational and educational to students throughout the world.

- a. What are NASA's plans to increase launches from PSCA?
- b. What roles does NASA expect PSCA to play in the agency's return of U.S. astronauts to the moon?
- c. What legislative considerations should congress consider to facilitate NASA's regular use of PSCA?

Answer. For the lifetime of NASA's acquisition of launch services for its payloads, we have maintained a position of launch site agnosticism in our contract mechanisms, allowing the needs of the particular mission as well as the concept of operations of our commercial partners to dictate which range we utilize. We have launched from the Eastern and Western ranges, from Kwajalein Atoll, Wallops Flight Facility, Spaceport Mojave, and Kodiak. While NASA intends to continue this approach, it is worth noting that one of our small launch providers, Astra Space, does routinely utilize Kodiak in its launch operations.

Question 2. Alaska's unique northern latitude and remote areas rely upon polar-orbiting and high-inclination orbiting satellites for a variety of key functions, including communications, disaster assessment and emergency response, and natural resource management. Rapid and responsive development and launch of small satellite technology holds promise to significantly improve and protect Alaskans' lives. NASA's CubeSat Launch Initiative is an exciting program to provide opportunities for small satellite payloads built by universities, high schools and non-profit organizations to fly on upcoming launches.

- a. What are NASA's plans to use the CubeSat Launch Initiative to address Alaska challenges?
- b. How will NASA ensure Alaska's satellite technology needs and Alaskans (e.g., universities, high schools and non-profit organizations) are included in the CubeSat Launch Initiative and similar programs?

Answer. In 2015 NASA selected and subsequently launched the ARC1 (Alaska Research Cubesat1) cubesat (1U) through a collaborative partnership with the National Reconnaissance Office. This Cubesat was designed and built by the University of Alaska Fairbanks. A follow on ARC2 was selected by CSLI in 2017 and was also selected as a participant in the USIP program in 2016. Unfortunately, COVID impacts to the project necessitated their request to withdraw from the CSLI, which we granted. Later this year, we will issue the 14th call for interested schools and universities to participate in CSLI. We would welcome entries from Alaska based institutions as we strive for diverse geographical representation in our Initiative.

Question 3. Space Debris has become an ongoing issue, costing the United States more money to monitor and track large debris in our low earth orbit. According to the Organization of Economic Cooperation and Development (OECD), almost 10 percent of costs related to managing and debris mitigation measures have been associated with space debris. What is NASA's plan to combat the debris issue as we increase our development in space and will this be set as a priority in future projects to develop new technology allowing for more sustainable practices?

Answer. Active Debris Removal is a technologically challenging endeavor with a high risk of failure given currently available technology and expertise. The challenge of orbital debris must be addressed by a whole of government approach based on three strategic pillars:

- Mitigate creation of orbital debris generation by design, operational controls, and end-of-life disposal and also through the development, dissemination, and adoption of orbital debris mitigation standard practices, guidelines and policies for domestic and international operators
- Improve our ability to detect and track debris too small to track with current technology;
- Support the development of Active Debris Removal (ADR) technologies and provide incentives and/or demand signal to commercial entities to develop ADR solutions to meet future government and commercial interests in space.

The ongoing work conducted under NASA's Orbital Debris Office is highly relevant to the whole of government approach. In coordination with other government agencies, NASA is funding early-stage research to focus on identifying concepts and approaches to de-spinning non-cooperative debris (e.g., how to capture tumbling debris), drag-enhancement devices, and deorbit of large objects. NASA is currently working on concept studies to identify remediation approaches, technology gaps and their prioritization, and to quantify the costs and benefits of ADR to aid planning on next steps. These studies are important because an unsuccessful ADR mission poses a serious risk of creating further orbital debris and could place other spacecraft at risk. While these studies are ongoing, NASA resources focused on ADR relevant technology are targeting applied to low- to mid-TRL technology research directed to reduce the risks and costs associated with ADR. Many important technologies continue to be funded by NASA Space Technology, including:

- proximity operations;
- sensors and instruments;
- efficient propulsion;
- guidance and navigation;
- autonomy;
- robotic manipulation;
- propellant refueling; and
- others through many funded projects and missions.

Each of these investments will go a long way toward identifying and creating a long term, sustainable approach to bulk remediation, which is needed to fully address the problem and to spur commercial investments.

Question 4. American leadership in space exploration and spaceflight relies on a capable, skilled, and well-trained STEM workforce to support NASA's work and the development of robust public-private partnerships in exploration. STEM Education is vital for the future of NASA and space-related jobs. The National Science Foundation found that the overall number of STEM bachelor's degrees awarded to men and women of almost all racial/ethnic groups has increased since 1977, with the exception of American Indian and Alaska Native men, for whom the numbers remain largely unchanged. How will NASA support and expand its STEM education efforts to support a skilled space workforce, especially for people of color, women, and indigenous Americans? How will you continue to make sure that space careers are accessible to young Alaskans, including Alaska Natives?

Answer. NASA EPSCoR works with Alaska through the offices of the Alaska NASA EPSCoR, located at the University of Alaska, Fairbanks. EPSCoR is actively funding eight Alaska research projects. Funding for three of the eight Alaska research projects was added in fiscal year 2021:

1. Cryogenic Solid Particle Erosion of Advanced Materials for Lunar Mission Applications (R3 award for \$100,000 for a 1-year period of performance)
2. Data assimilation and modeling to improve snow water equivalent assessment in Alaska (Research NOFO for \$750,000 for a 3-year period of performance)
3. Alaska Research Infrastructure Development (RID award for \$1,000,000 for a 5-year period of performance)

In fiscal year 2021 the University of Alaska-Fairbanks received \$800,000 in Space Grant funding to continue work within the State to deliver NASA content and student-centric programming to approximately 500 students and educators.

Within Next Gen STEM, a TEAM II Community Anchor award (\$25,000) was made to the Challenger Learning Center of Alaska to explore NASA's ongoing research into sustainable food production for space exploration and how the methods mirror and contribute to efforts toward Food Security in Alaska.

MUREP recently awarded the University of Alaska-Fairbanks an OCEAN award in fiscal year 2021 for \$250,000/per year for 3 years to focus on Earth Science efforts in collaboration with NASA SMD.

QUESTIONS SUBMITTED BY SENATOR JOHN KENNEDY

Preface to Questions 1 through 6:

The NASA Michoud Assembly facility in New Orleans is NASA's "Rocket Factory." Michoud has been a part of NASA Human Space Flight since the beginning of NASA. It has weathered budget ups and downs, as well as the natural disasters of Hurricanes Betsy in 1965 and Katrina in 2005, and an EF3 (136–165 mph) tornado in February 2017. Nevertheless, Michoud hasn't missed a beat, in spite of NASA's lack of commitment to invest in repairs at the Michoud Assembly Facility. This is a testament to the working spirit of the Louisiana people who work at Michoud. Despite this performance record, the facility is in need of repairs and improvements. For example, in Building 103, space flight hardware is placed to dodge water from the leaking roof while billions are spent on less essential, new buildings at other centers. This is baffling because if rockets aren't built at Michoud, launches cannot occur at the Kennedy Space Center. Consequently, I am concerned about the disparity in infrastructure investment between manufacturing facilities like Michoud and Stennis versus other test and launch facilities.

Question 1. What is the facility and assembly plant 5-year budget plan to ensure Michoud is modernized and can handle the throughput of the Space Launch System (SLS) to remain NASA's Rocket Manufacturing Plant for decades to come?

Answer. At the Michoud Assembly Facility (MAF), Building 103 required investment due to hurricane damage. Public Law 117–43 (H.R. 5305) *Extending Government Funding and Delivering Emergency Assistance Act*, provided \$321,400,000 in supplemental funding to be used for facilities damaged by Hurricanes Zeta and Ida. Approximately \$241,800,000 of this funding was directed to MAF for facilities repair including repairs to Building 103 Roof, other buildings and critical infrastructure. Approximately \$48,200,000 was directed to repair Flight Hardware damaged during the Hurricanes.

Question 2. How does that compare to NASA's investments over the last 5 years in launch facilities?

Answer. NASA programs provide programmatic funding for Construction of Facilities to meet mission requirements. Over the 5-year period (fiscal year 2019–fiscal year 2023) ESDMD and the emergency funding referred to above, provided \$382.9M for MAF. In the same 5-year period ESDMD provided \$232.3M to KSC which also included other nonlaunch facility specific funding.

Question 3. How many of the Space Launch System (SLS) core stages are under contract to be built at Michoud and what is the delivery schedule?

Answer. Contract is definitized and provides scope for the following:

- Core Stages 1 (delivery to KSC January 2021) (CS 1 actual delivery date to KSC April 2021)
- Core Stage 2 (contract delivery schedule is March 2022 with a forecast NET March 2023)

- Forecast delivery date driven by impacts of COVID/Hurricanes ~5 months and Performance of ~7 months
- Exploration Upper Stage 1 (delivery to KSC February 2025)
- Long Leads for Core Stage 3

Question 4. What is the completion schedule for the Space Launch System (SLS) core stages to be manufactured and assembled at Michoud?

Answer. The completion schedule for Core Stage 3 and beyond are subject to definitization of the Stages Production and Evolution Contract (SPEC). In October 2019, a Letter Contract was issued for the SPEC (Flights Sets 3–12) and in April 2020 a Request for Proposal (RFP) was issued (Flights Sets 3–12). At this time, all necessary work to allow continued production is authorized under the letter contract and there is no delay relative to core stage production for Artemis missions. The RFP definitizes the letter contract from a pricing perspective. The RFP proposal submission was received in March 2021. While there have been Government driven requirement changes, the contractor requested to descope the RFP, essentially reducing the order quantity for this negotiation due to uncertainty in things such as out-year commodity pricing. The current scope of the negotiations includes CS 3–4 and materials for CS 5–6 and EUS 2–3. In order to complete the technical evaluations, 70 Request For Information (RFIs) were issued to support closure of the Government's evaluation. NASA and Boeing have been actively engaging to negotiate an agreement throughout this period of time, while the Agency also engages at the corporate level to help facilitate ongoing negotiations.

Question 5. Has NASA placed any emphasis on partnering with Louisiana companies to promote hiring locals who possess generational knowledge of Michoud to ensure NASA's success over the long haul? If so, how is NASA emphasizing partnering with Louisiana?

Answer. Yes, MSFC/MAF have been promoting the local Universities and Technical Colleges to Tenants at MAF as a resource for hiring technicians and engineers. They have also provided local University job placement point-of-contact information to the NASA Prime Contractors and facilitated introductions. NASA/MAF has partnered with IRG Corp. to lease land for a manufacturing complex. An Enhanced Use Lease was signed for that piece of real estate, although the company has not yet started construction. Also, NASA/MAF partnered with GNO Inc. and Louisiana Economic Development (LED) for new MAF Tenant opportunities. Although a lease has not been agreed to at this time, collaborative partnerships with Louisiana companies on local and State initiatives, MAF greenspace development, and regional development opportunities could support the NASA/MAF and surrounding community.

Question 6. NASA's fiscal year 2021 proposed budget is NASA's highest budget ever to support the mission to the moon and on to MARS, but it essentially eliminates funding, by delaying funding, for the Exploration Upper Stage (EUS). I understand your need to balance resources, but why isn't this in your list of highest priorities over other projects and programs elsewhere in the NASA budget?

Answer. EUS funding has been at levels appropriate for the planned work. The fiscal year 2021 and fiscal year 2022 appropriated levels were \$400,000,000 and \$600,000,000, respectively.

Preface to Question 7:

As I understand, your Headquarters and Marshall Space Flight Center have been briefed on ongoing discussions between the State of Louisiana, local officials, and NASA leadership at Michoud about potential State, local and/or private partnerships to upgrade and provide state of the art administrative and office facilities for NASA as well as commercial and other tenants at Michoud. These talks include possible solutions to a new facility and spaces for USDA's National Finance Center (NFC) that has been a tenant at Michoud for decades and whose buildings were essentially destroyed by a tornado in February 2017. I believe these improvements are necessary to the Space Launch System (SLS) as well as the work of the National Finance Center.

Question 7. What is the most effective way to get these improvements done for the benefit of NASA, the taxpayers, as well as NASA's current commercial and government tenants including the National Finance Center?

Answer. The possible development of state-of-the-art administrative and office facilities at MAF are not necessary for the SLS program. NASA has modified a large amount of space in the Building 102 and Building 103 complex and can easily ac-

commodate any increase in the Boeing workforce at MAF for the SLS program should that become necessary. It is important to note that future growth in workforce at MAF for NASA programs may not be necessary.

We are not informed of the latest planning by USDA for the National Finance Center occupancy needs beyond their current arrangements with NASA.

The private investment in office space at MAF will be most effectively accomplished with a Real Property lease arrangement and then letting private investment with market forces drive the effort.

Question 8. NASA's fiscal year 2021 proposed budget redirects funds from lower priority programs to fulfill the President's promise to get Americans back to the Moon. Please describe which major programs loss funding and the extent to which these programs have been impacted.

Answer. Major Exploration and Space Operations programs, projects and activities contribute to the overall success of the Artemis Missions and are sufficiently funded. No major programs were decremented in order to redirect funding to "higher" priority programs.

QUESTIONS SUBMITTED BY SENATOR MARCO RUBIO

Question 1. (Exploration Ground Systems) I'm concerned with the more than \$200,000,000 decrease in funding for the Exploration Ground Systems (EGS) in the fiscal year 2021 budget proposal. This would have a significant negative impact on the Kennedy Space Center (KSC) and could cause delays in the Artemis program such that a 2024 target date for landing on the moon may have to be pushed back. Can you please reaffirm your commitment to ensuring the EGS gets the proper funding it needs to ensure the 2024 target date remains in place?

Answer. The EGS program is funded at levels appropriate for the planned work. The fiscal year 2021 Appropriation was within 1 percent of the previous two fiscal years.

Question 2. (Civil Aerospace Competition with China and Russia).—According to the *2019 Report to Congress of the U.S.-China Economic and Security Review Commission*, "China is taking steps to establish a commanding position in the commercial launch and satellite sectors, relying in part on aggressive state-backed financing that foreign market-driven companies cannot match." Furthermore, the report adds that, "China has already succeeded in undercutting some U.S. and other foreign launch and satellite providers in the international market, threatening to hollow out these countries' space industrial bases." NASA rightly makes a priority of supporting a robust space industrial base and working with the domestic commercial space industry. Do you agree that Chinese government efforts to drive competitors out of the market are of significant concern to the strength and long term health of the American space industrial base and commercial space industry?

Answer. NASA supports robust domestic commercial space activities. The Agency invests in U.S. Space Technology Research and Development that will support new technologies to strengthen the U.S. commercial space industry, enhance mission capabilities, create good-paying jobs, and reduce costs. These investments are key to ensuring American leadership and bolstering against international competition.

Question 3. (Continued) What additional steps can NASA take to incentivize the growth of the U.S. commercial space sector to counter this threat?

Answer. NASA is using competitive services contracts for efforts related to Artemis where appropriate. For example, NASA's Commercial Lunar Payload Services (CLPS) initiative allows rapid acquisition of lunar delivery services from American companies for payloads that advance capabilities for science, exploration, or commercial development of the Moon. In addition, NASA will utilize competitive services for such items as spacesuits and support services for spacewalks during Artemis lunar surface missions, as well as for Deep Space Logistic Services and is exploring purchasing services for communications and sustaining lunar transit services. In addition, NASA is partnering with industry to achieve commercial economy in Low Earth Orbit (LEO).

Question 4. (Continued) What steps can we take to further include small businesses working in partnership with NASA?

Answer. NASA's Office of Small Business Programs (OSBP) primary mission since its inception has been to increase the representation of small businesses in NASA's

contracting efforts. Our efforts encompass all federally recognized socio-economic small business categories and we work hard to make sure each type of business gets a fair opportunity to work with NASA. <https://www.nasa.gov/osbp>

OSBP uses the following tools to increase participation of small business in procurement at NASA:

- The NASA Vendor Database (NVDB) is open to all vendors, both large and small, who wish to do business with NASA. Interested businesses register online; and the current vendor list is uploaded to the OSBP website at the end of each month. Members of the NVDB community receive an easily navigable Microsoft Excel file containing a vendor registration list monthly, which enables them to conduct market research, a vendor search, Minority Serving Institutions (MSIs) search and capability statement viewing. <https://www.nasa.gov/osbp/nasa-vendor-database>
- The OSBP Learning Series are monthly webinars that provide in-depth training relevant to small businesses. These webinars allow companies the opportunity to ask questions directly to subject matter experts who provide knowledge on how to obtain Federal Government contracts. <https://www.nasa.gov/osbp/learning-series>
- NASA OSBP is committed to “promoting small business awareness and participation, utilizing innovative techniques at nontraditional venues in geographically targeted areas, to enhance all categories of small business.” NASA OSBP participates in and hosts outreach event(s) which includes supporting congressional outreach events. <https://www.nasa.gov/osbp/regional-outreach>
- NASA OSBP oversees the NASA Mentor Protégé Program (MPP) which is one of five MPPs that the U.S. Small Business Administration (SBA) allowed to continue functioning apart from the SBA’s “All Small MPP”. This was done primarily because of the special emphasis NASA places on diversity and inclusion among all small businesses eligible to participate as protégés in the program (i.e., Small Business (SB), Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB), Historically Underutilized Business Zone (HUBZone), Veteran-Owned Small Business (VOSB), Service-Disabled Veteran-Owned Small Business (SDVOSB), and MSIs/Historically Black Colleges and Universities (HBCU)). <https://www.nasa.gov/osbp/mentor-protége-program>
- The NASA Acquisition Forecast identifies future procurement opportunities at the agency over the Simplified Acquisition Threshold that could potentially be set-aside for the SBA’s 8(a) Business Development Program, WOSB, HUBZone, VOSB, or SDVOSB. <https://www.hq.nasa.gov/office/procurement/forecast/>
- The Active Contract Listings (ACLs) are unique to NASA. The ACLs provide vendors interested in doing business with the agency with a list of recurring requirements. This list provides vendors with the pertinent contract information which allows interested parties to compete for the follow-on contract. <https://www.nasa.gov/osbp/active-contract-listings>
- The NASA OSBP Mobile App is designed as a user-friendly tool and has information to assist companies in how to do business with NASA. Key features allow users to easily contact NASA Center Small Business Specialists, view Active Contract Listings, and find out when upcoming networking events are taking place. <https://www.nasa.gov/osbp/mobile>

Question 5. (Continued) China and Russia have made clear that they view space as important to modern warfare and see counter space capabilities as a means to reduce U.S. and allied military effectiveness. Both of these nations have made efforts to militarize their space operations. How is NASA prepared to navigate this climate to continue its critical focus on civil space?

Answer. NASA is focused on enabling missions on and around the Moon through Artemis while preparing for Mars exploration. NASA investments in deep space exploration through the Artemis missions will land the first woman and first person of color on the lunar surface, demonstrate American leadership, deepen and broaden America’s international partnerships, increase the scientific understanding of the Moon, and test technologies that will prepare for human exploration of Mars.

Question 6. (Continued) Does this impact NASA’s lunar mission as a whole, or any portion of the timeline?

Answer. NASA is cognizant of the counter space capabilities of China and Russia but remains focused on our civil space exploration plans. Specifically, Artemis is the first step in the next era of human exploration. Together with commercial and international partners, NASA will establish a sustainable presence on the Moon to prepare for missions to Mars. NASA is on track to launch Artemis I, the first inte-

grated test of NASA's deep space exploration systems: the Orion spacecraft, Space Launch System (SLS) rocket and the ground systems, later this summer from the Kennedy Space Center in Cape Canaveral, Florida. The first in a series of increasingly complex missions, Artemis I will be an uncrewed flight test that will provide a foundation for human deep space exploration and demonstrate our commitment and capability to extend human existence to the Moon and beyond.

Question 7. (Continued) How important is the establishment of the Space Force to ensuring the safety of our space programs?

Answer. NASA strongly supports establishment of the Space Force as a needed response to the counter space capabilities of China and Russia.

Question 8. (Continued) Can you speak to the Artemis Accords and the importance of an international agreement to the peaceful use of space for scientific research?

Answer. On October 13, 2020, the United States was joined by seven countries (Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, and the United Kingdom) in signing the Artemis Accords. These nations, and those that have since signed (Bahrain, Brazil, Israel, New Zealand, Mexico, Poland, Romania, South Korea and Singapore and Ukraine—a total of 18 to date), demonstrated their commitment to a common set of principles to govern the civil exploration and use of outer space. NASA and the Department of State believe that the Accords play an important role in achieving a sustainable and robust presence on the Moon while preparing to conduct a historic human mission to Mars. As such, we continue to engage multiple countries on the Artemis Accords, and anticipate the list of signatories to continue to grow.

Question 9. (Indian River Bridge).—The Indian River Bridge provides the main route to KSC and its Visitors Complex and offers the only route to launch pads for national security, science and commercial spacecraft. However, the nearly 60-year-old bridge has significantly aged and a NASA engineering study in 2017 determined the bridge needs to be replaced. Can you speak to the importance of infrastructure at KSC, such as Indian River Bridge, to our domestic space industry?

Answer. NASA is committed to the stewardship and maintenance of the Indian River Bridge (IRB) on KSC to ensure that the Nation can continue to have unfettered access to space for civil, national security and commercial launches.

Question 10. (Continued) What steps has NASA taken to ensure that KSC is aware of NASA's commitment to replacing the bridge?

Answer. NASA funded a Federal Highway managed, Florida Dept of Transportation (FDOT) design and environmental study to enable the IRB replacement bridge to be able to compete for other Federal and State fund sources.

Question 11. (Continued) What steps has NASA taken to work with relevant State and local agencies to ensure critical infrastructure needs are met?

Answer. NASA has engaged with multiple Federal and State agencies to determine a multi-party funding solution for replacement of the IRB. NASA is in negotiations with the State of Florida to utilize a USDOT INFRAGrant to construct a new bridge to access the spaceport. The Grant was awarded in 2019 and construction of a new bridge is expected to begin in the fall of 2021.

QUESTIONS SUBMITTED BY SENATOR CHRIS VAN HOLLEN

Question 1. The James Webb Telescope launch date has been postponed from March 2021 to October 2021, and the agency had cited COVID-19 as the reason behind the delay. How has COVID-19 impacted missions, and what steps is the agency taking to ensure that missions are not missing crucial launch windows?

Answer. COVID impacts to integration and test activities for the James Webb Space Telescope (Webb) led, in part, to a launch delay past October 2021. However, NASA worked closely with its U.S. commercial partners, the European Space Agency, and Arianespace to ensure a successful launch on December 25, 2021. Webb is currently undergoing commissioning at its final location in space and is expected to produce the first scientific images in summer of 2022.

Question 2. The NASA Science Mission Directorate recently shared with the research community that in order to protect graduate students and early career researchers from pandemic job impacts, it will need to reduce approximately 15 per-

cent of funding available for new awards in fiscal year 2021. This reflects a significant cut to future activities supporting NASA Science.

If Congress wants to reverse this cut to new research and analysis (R&A) activity, what amount of emergency funding would be necessary? Additionally, do you share concerns about the pandemic's impact on the future NASA science and engineering workforce and our national competitiveness in these areas?

Answer. In response to the pandemic, each science division within the Science Mission Directorate (SMD) increased their support to graduate students and early career researchers in fiscal year 2021 by doing special solicitations and extensions specific to the needs of their communities. NASA SMD continues to monitor the impact of COVID on all our programs and projects. SMD has been intentionally engaging the early career demographic via round table discussions and other forums to maintain and grow a strong NASA science and engineering workforce despite disruptions from the pandemic on careers, focusing especially on women and traditionally underserved communities that have been hit disproportionately by COVID impacts.

Question 3. In early August, Wallops Flight Facility contract worker, Anthony Selby, sadly passed away from COVID-19. What steps is the agency taking to ensure the safety of workers, including contract workers, during the COVID-19 pandemic?

Answer. The Agency has a senior level task force for COVID that meets several times per week. The Agency has followed all CDC, White House Safer Federal Workforce Guidance. The Agency has implemented controls and safeguards recommended by OSHA, CDC, and the WH Safer Federal Workforce Task Force to include public health controls, promoting vaccination, masking, social distancing, and air quality control measures when such measures were warranted based on case rates and hospitalizations. The Agency continues to make efforts to provide a safe workplace in order to protect employees.

Question 4. In 2017, PFAS were detected in Wallops Flight Facility and the Town of Chincoteague drinking water wells. NASA has stated that it is conducting groundwater testing and had been installing a groundwater treatment system for the Town of Chincoteague, but there was a suspension of this work because of COVID-19. What is NASA doing to make progress on this?

Answer. NASA resumed this work during COVID-19, completing the groundwater treatment system for the Town of Chincoteague, which began operations at the end of April 2021. As of February 28, 2022, the system has treated over 34 million gallons of water, and ongoing testing continues to show the system is effectively removing PFAS to below detection levels.

Question 5. The CARES Act Section 3610 granted contract flexibility to agencies. As the pandemic's impact continues, how important is this contract flexibility for the agency? What would happen if the authority were not extended regarding the timeline of missions and the impact on the NASA workforce?

Answer. As of September 30, 2021, when the CARES Act expired, NASA no longer uses any of the existing authorities afforded by the CARES Act Section 3610. The agency shifted its approach and continued to leverage current laws, regulations, and policies that would enable the Agency to preserve the Readiness of the Space industrial base and Mission Operational Readiness during this COVID-19 pandemic. The NASA Office of Procurement and Office of General Counsel, identified the following authorities, prior to the CARES Act; and these authorities were included in our March 24, 2020 notification issued to the NASA Contractor Community, both on-site and off-site:

- Stop Work Clause. FAR 52.242-15 Stop Work Order (Offsite), when a contractor informs us that they cannot safely perform work at their facilities, either because of State guidelines or their own internal assessment; and or applicable clause such as 52.212(4) T&C for Commercial Items; and
- Denied Access Clause. NFS 1852.242-72 Denied Access, when a NASA Facility is closed and there is no work that a Contractor or their employee can accomplish from a remote location.

These authorities instruct contractors on the authorities that NASA used/is using to Preserve the Readiness of the Space Industrial Base and to maintain Mission Operational Readiness and continue to be used today in our contracts.

CONCLUSION OF HEARINGS

With that, the subcommittee stands in recess.

[Whereupon, at 3:21 p.m., Wednesday, September 23, the hearings were concluded, and the subcommittee was recessed, to reconvene subject to the call of the Chair.]