National Aeronautics and
Space Administration

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Committee on Commerce, Science, and Transportation

United States Senate

Statement by:
James F. Bridenstine
Administrator

116th Congress

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Overview

Chairman Wicker and Members of the Committee, 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 FY 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 FY 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 FY 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 FY 2021. This budget provides the resources we need in FY 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 FY 2021 resources NASA's Human Exploration Operations Mission Directorate needs to support a robust exploration program. The FY 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 FY 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 FY 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 FY 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 ten 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 FY 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 FY 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 FY 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 FY 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 FY 2019 and FY 2020 budget requests, the FY 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 one-year technology demonstration.

Aeronautics

NASA's FY 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 FY 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 FY 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 FY 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 FY 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 FY 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 FY 2021, NASA will strengthen cybersecurity capabilities, safeguarding critical systems and data, while also providing funding to modernize NASA's IT systems.

Conclusion
The FY 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.