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Statement of

The Honorable Charles F. Bolden, Jr.
Administrator
National Aeronautics and Space Administration

before the

Subcommittee on Space
Committee on Science, Space, and Technology
United States House of Representatives

Mr. Chairman and Members of the Committee, I am pleased to have this opportunity to discuss NASA's FY 2017 budget request. The President is proposing an FY 2017 budget of more than $19 billion for NASA, building on the strong and consistent support NASA has received from this Committee and the Congress. This request, which includes both discretionary and mandatory funding, will allow NASA to continue to lead the world in space through a balanced program of exploration, science, technology, and aeronautics research.

Of note, within this request, NASA is proposing a ten-year plan that would significantly accelerate aeronautics research. We seek support from congress for a substantial increase in funding for aeronautics that will support a vigorous flight demonstration program to demonstrate and validate technologies to dramatically improve the aircraft of the future. We are ready to test these technologies and concepts as integrated systems by developing "X-plane" demonstrators. The United States leads the world in aviation, but this leadership can only be maintained by a vigorous program of research to create the efficient aircraft of the future.

NASA is positioned for a vibrant future, and we look forward to the long term support that will enable the Agency to continue leading the world into space and on the journey to Mars. We are on track for the key near-term steps on that journey with flight certification of our commercial crew transportation systems in 2017, and the launch of Exploration Mission 1 (EM-1) in 2018. In 2016, the Juno Spacecraft will orbit Jupiter while Cassini will execute its dramatic "Grand Finale" orbits of Saturn. The Solar Probe Plus (SPP), Transiting Exoplanet Survey Satellite (TESS) and the James Webb Space Telescope (JWST) are on track to launch in 2018, and a new Mars rover is in development for a 2020 launch on its way to join the spectacular Curiosity rover now exploring the planet. NASA's missions are providing the critical data we need to understand the home planet, our nearby star, every planet in the Solar system, and the universe. We are accomplishing all this while consistently improving program performance: GAO reports that overall development cost growth for the portfolio of major development programs it tracks, excluding the James Webb Space Telescope (JWST), fell to 1.3 percent, at or near the lowest levels we have reported since GAO began annual reviews in 2009. Relying on the consistent support of Congress, the Agency remains on a sustainable path to accomplish a world-leading program of exploration and discovery in space. The Agency is well positioned to continue on its long-term mission, and, by focusing on executing the plan we have laid out, we intend to earn the continued support of future Administrations and Congresses for this plan.

Human Exploration and Operations

The FY 2017 President's Budget Request continues NASA's Journey to Mars, extending our reach in space with the specific goal of sending human missions to Mars, and the broader aim of establishing a sustainable human presence beyond Earth. NASA's exploration strategy is to evolve from today's Earth-reliant posture to conducting missions in the Proving Ground of cislunar space and then to the Earth-independent capability needed to extend human presence into the solar system and to the surface of Mars. The FY 2017 request includes $3,336.9 million for Exploration, with $2,859.6 million for Exploration Systems Development, and $477.3 million for Exploration Research and Development. The FY request also includes $5,075.8 million for Space Operations, including $1,430.7 million for the International Space Station (ISS), $887.4 million for Space and Flight Support, and $2,757.7 million for Space Transportation – both commercial crew system development and on-going crew and cargo transportation services that resupply ISS.

The first step on the Journey to Mars is our current activity in low Earth orbit (LEO), where research and technology development activities conducted aboard ISS are delivering the knowledge we need to keep our astronauts safe, healthy and productive on deep-space missions of increasing durations. ISS research is advancing the fundamental biological and physical sciences for the benefit of humanity, improving life on Earth and adding to our understanding of the universe. The ISS is the cornerstone of our exploration strategy, a nearby outpost in space where humanity is taking its early steps on its journey into the solar system, and we appreciate the action Congress took last year to authorize continued Station operations through at least 2024, consistent with the President's request.

Under the Commercial Resupply Services (CRS) contracts, our two commercial cargo partners, Space Exploration Technologies (SpaceX) and Orbital ATK, have demonstrated not only the ability to provide cargo deliveries to ISS, but also the flexibility to recover effectively from mishaps. Both companies have worked closely with NASA to understand the anomalies they experienced over the last year and a half. In developing the launch vehicles for their cargo spacecraft, SpaceX and Orbital ATK have also helped to bring some of the commercial satellite launch market back to the U.S., and helped to lower commercial launch costs. This January, through CRS-2, NASA contracted with SpaceX, Orbital ATK, and Sierra Nevada Corporation to ensure that critical science, research and technology demonstrations will be delivered to the ISS from 2019 through 2024. Our commercial crew partners, SpaceX and the Boeing Company, are developing the Crew Dragon and CST-100 Starliner spacecraft, respectively. The work, being done under two Federal Acquisition Regulation (FAR)-based, fixed-price Commercial Crew Transportation Capability (CCtCap) contracts, is expected to result in flight certification of their crew transportation systems by the end of calendar year 2017. In 2015, NASA ordered the initial post-certification missions, and in 2016, milestone completion and work are progressing well. 2017 will be an exciting and challenging year as we work with our partners to launch the first new human spaceflight capability in a generation.

Under the auspices of the ISS National Laboratory, managed by the Center for the Advancement of Science In Space (CASIS), NASA is encouraging broader use of the ISS by non-traditional companies and other Government agencies. The ISS National Lab has reached full capacity for allocated crew time for research that was both scientifically and economically reviewed for terrestrial benefit.

As we move out into the Proving Ground of cislunar space, we will employ new deep-space systems, including the heavy-lift Space Launch System (SLS), Orion crew vehicle, the Exploration Ground Systems (EGS) that support them, and new deep space habitation capabilities developed through public-private partnerships. We will also continue to invest in exploration research and development that will make future missions safer, more reliable, and more affordable. NASA's initial deep-space mission,

EM-1, is on track to launch to a distant retrograde orbit in the Proving Ground around the Moon in 2018. In 2015, the Agency conducted a key decision point review of the Orion program, establishing an Agency baseline commitment level for Orion that supports a 2023 launch readiness date for EM-2. The FY 2017 budget fully funds the Agency baseline commitment level. In the initial phase of our Proving Ground operations, NASA will use this region of space to test and demonstrate flight and mission operations and staging of human-rated vehicles farther from Earth than ever before. Crewed Orion missions launched on the SLS in the 2020s will establish our capability to operate safely and productively in deep space.

SLS and Orion are critical to human spaceflight beyond LEO. The NASA-Industry teams building SLS and Orion have made tremendous progress over the last year in building and testing vehicle components. For SLS, the Core Stage qualification and EM-1 flight barrels are awaiting vertical welding at the Michoud Assembly Facility (MAF), the RS-25 flight engines are all assembled and awaiting engine controller installation, and production of the final booster qualification motor is nearly complete. For Orion, the EM-1 Crew Module pressure vessel welding is complete, the European Service Module structural testing is in progress, and software testing is underway in the Integrated Test Lab. In EGS, Mobile Launcher structural mods are complete, the Vehicle Assembly Building High Bay 3 platforms are being installed, and Crawler Transporter mods are underway.

Subsequent missions in the Proving Ground will target challenges and strategic knowledge gaps while helping develop the core capabilities necessary to expand human activity farther into deep space, culminating in demonstration of a long-duration (one-year plus) deep-space habitation capability, critical preparation for crewed missions to Mars. The FY 2017 request includes the funding to support work on the required habitation systems. Our FY 2017 budget includes $90 million to support habitation systems development. This work includes the second phase of the Next Space Technologies for Exploration Partnerships (NextSTEP) Broad Agency Announcement, an effort to stimulate deep-space capability development across the aerospace industry. Through these initial public-private partnerships, NextSTEP partners will provide advanced concept studies, technology development projects, and significant measurements in key areas, including habitat concepts, environmental control and life support systems, advanced in-space propulsion, and small spacecraft to conduct missions related to Strategic Knowledge Gaps. The NextSTEP efforts are a key component of our overall strategy to move into the Proving Ground.

NASA will continue to develop the Asteroid Redirect Mission. This will include a robotic mission that will remove a multi-ton boulder from a target asteroid and use solar-electric propulsion to move the boulder into lunar orbit. A human mission using the SLS and Orion vehicles will then rendezvous with and take samples from this asteroidal mass. The mission demonstrates the use of advanced solar-electric propulsion, automated rendezvous and complex crew operations in the Proving Ground of lunar orbit, and improves NASA's ability to identify and respond to potentially dangerous asteroids.

Space Technology

NASA's FY 2017 request includes $826.7 million for Space Technology to conduct rapid development and incorporation of transformative space technologies to enable NASA's future missions, increase the capabilities of other US agencies, and address aerospace industry challenges. NASA's Space Technology program has developed a diverse portfolio creating a technology pipeline to solve the Agency and Nation's most difficult challenges in space. Space Technology will continue to prioritize "tipping point" technologies and early-stage innovation with approximately 600 awards to industry and small businesses, private innovators, and academia to spark new ideas for the benefit of NASA as well as the broader US aerospace and high tech sectors. As efforts complete, appropriate technologies will be transferred and commercialized to benefit a wide range of users ensuring the nation realizes the full economic value and societal benefit of these innovations. Technology drives exploration by continuing maturation of enabling

technologies for future human and robotic exploration missions including deep space optical communications to return more data and improve operations; improved carbon dioxide removal and oxygen recovery systems for more efficient life support and environmental control capabilities; nuclear thermal propulsion technologies for rapid in-space transit; robotics and autonomy to reduce mission cost and risk; and advancements in remote sensing instruments and spacecraft subsystems to reduce size, weight and power requirements enabling lower cost missions utilizing small spacecraft.

The program will take a major step early next year with the launch of the Green Propellant Infusion Mission (GPIM). GPIM will demonstrate on-orbit a propellant that has higher performance and is much safer to handle than the hydrazine fuel that is now commonly used for in-space propulsion systems.

In FY 2017, building on the Robotic Refueling Mission technology demonstrations on ISS, the program will continue mission formulation for Restore-L, a mission to advance and demonstrate the capability to service and refuel satellites on orbit with the potential to add life to existing satellites worth billions of dollars.

In support of the Asteroid Redirect Robotic Mission (ARRM), Space Technology continues development of high-powered solar electric propulsion technologies that will enable extremely efficient orbit transfer and accommodate increasing power demands for government and commercial satellites.

Also in FY 2017, the Mars Oxygen In Situ Resource Utilization Experiment (MOXIE) payload on the Mars 2020 mission will hold a Critical Design Review. The payload will demonstrate the in situ production of oxygen on Mars, a technology that could furnish oxygen for breathing and fuel on future Mars missions. The Laser Communications Relay Demonstration project will complete its Critical Design Review and Key Decision Point - C, and will continue hardware fabrication to support a late CY 2019 launch readiness date.

Science

NASA's science vision is to use the vantage point of space to achieve with the science community and our partners a deep scientific understanding of our home planet, the Sun and its effects on the solar system, other planets and solar system bodies, the interplanetary environment, and the universe beyond. The President's FY 2017 budget requests $5,600.5 million for NASA's Science program including $2,032.2 million for Earth Science, $1,518.7 million for Planetary Science, $781.5 for Astrophysics, $569.4 million for the James Webb Space Telescope, and $698.7 million for Heliophysics.

From orbit, NASA satellites advance our knowledge of our dynamic and complex home planet, Earth. In addition to driving scientific discoveries, NASA Earth-observing research satellite missions collect essential measurements that serve national interests. Our NASA satellites monitor regional and global food and water security and air quality, support disaster response, and contribute to economic growth. Nineteen NASA research missions – five of which were launched in a span of 11 months from 2014 to 2015 – are orbiting the Earth and providing key measurements today. The Global Precipitation Measurement mission has already produced the first global rain and snowfall map, and the constellation routinely observes precipitation over the entire globe every 2-3 hours. The ISS Rapid Scatterometer, the first science payload to be robotically assembled in space since the ISS itself, measures surface ocean wind speeds and directions. And the Soil Moisture Active and Passive mission provides global, high-accuracy soil moisture and sea-surface salinity measurements at 35 km resolution.

In 2016, three launches will add significantly to our capabilities. On January 17, NASA launched the Jason-3 satellite, a mission led by NOAA and EUMETSAT, along with our French partner CNES. Jason-3 is the fourth mission in a U.S.-European series using precision altimetry to measure ocean surface

topography – the hills and valleys of the ocean surface. Later in the year, the SAGE-III (Stratospheric Aerosol and Gas Experiment-III) instrument will launch to the ISS to obtain atmospheric trace gas profile data, including ozone measurements, with the Lightning Imaging Sensor as a secondary payload. In October, a constellation of eight micro-satellites called the Cyclone Global Navigation Satellite System (CYGNSS) will become NASA's first Earth Venture Mission small-sat constellation, to investigate the evolution of tropical cyclones and hurricanes. The FY 2017 request supports development of new missions including the Ice, Cloud, and land Elevation Satellite-2 (ICESAT-2) and the Gravity Recovery and Climate Experiment Follow-on (GRACE-FO) that provide continuity for key long-term measurements.

NASA is building Landsat 9 as part of our Sustainable Land Imaging (SLI) architecture that will continue our Nation's accurate measurement of Earth's land cover. NASA and the U.S. Geological Survey (USGS) initiated Landsat 9 in March 2015 and it is being built as a near-copy of Landsat 8 for launch in the 2021 timeframe. The SLI program will work closely with industry to support and infuse advanced satellite, scientific instrument, and overall system technologies into future missions. The robust SLI architecture ensures that high-quality Landsat imagery, freely accessible in an open archive, will continue to be available for critical uses such as monitoring the irrigation of farmland in the American West.

NASA's Astrophysics program continues to operate the Hubble, Chandra, Spitzer, Fermi, and Kepler space telescopes, the Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne observatory, and other missions that together comprise an unrivaled resource for the study of our universe. NASA's next strategic Astrophysics mission, the James Webb Space Telescope, continues on schedule for its 2018 launch and remains within budget.

With this year's request, NASA will continue developing the Transiting Exoplanet Survey Satellite (TESS) for launch in 2018. TESS will extend the pioneering exoplanet discoveries of the Kepler Space Telescope by looking for rocky exoplanets orbiting the nearest and brightest stars in the sky in time for Webb to conduct follow-up observations. During FY 2017, NASA will also continue formulation of the Wide-Field Infrared Survey Telescope (WFIRST), the top priority for large-scale missions of the most recent National Academy of Science Decadal Survey in Astronomy and Astrophysics.

With the FY 2017 budget request, NASA will broaden its reach into the Solar System with increasingly capable missions and continue to produce a series of exciting achievements in planetary science. In one of the biggest stories of the past year, NASA's New Horizons spacecraft captured our imaginations by showing us the complexity of one of our most distant and smallest neighbors. And despite being far beyond Pluto now, the intrepid probe continues to send volumes of pictures and other data over a radio link to Earth stretching billions of miles. At the same time, the Juno spacecraft is on its way to Jupiter where it will achieve a first-ever polar orbit of the gas giant this July 4th. And just two short months later, NASA's robotic asteroid rendezvous and sample return mission, dubbed OSIRIS-REx, will launch to the near Earth asteroid, Bennu, where it will collect a sample for return to Earth in 2023. In late 2016, after more than ten years of exploration, the Cassini spacecraft will begin a daring set of orbits called the Grand Finale that is, in some ways, like a whole new mission. The spacecraft will repeatedly climb high above Saturn's poles before probing the water-rich plume of the active geysers on the planet's intriguing moon Enceladus, fly by Titan, and then dive between the planet and its innermost ring 22 times. No other mission has explored this unique region so close to the planet. Moreover, the FY 2017 request supports several other missions operating throughout the Solar System. These include the Curiosity rover at Mars, the Lunar Reconnaissance Orbiter, the Dawn spacecraft currently at Ceres, and the Mars Atmosphere and Volatile EvolutioN (MAVEN) orbiter.

Looking to the future, the FY 2017 request continues development of a new rover that in 2020 will carry seven carefully selected instruments to conduct exceptional science as well as for the first time ever,

cache a Mars sample for a potential later return to Earth. The budget also continues formulation for a mission to Jupiter's moon, Europa, to explore the most likely host of current life beyond Earth. In addition, this year's request releases a new announcement of opportunity for NASA's New Frontiers Program and selects at least one new Discovery mission for development – ensuring this essential path of exploration for the next decade.

NASA's Heliophysics program operates 18 active missions comprising 28 spacecraft, called the Heliophysics System Observatory (HSO), to understand the Sun and its interactions with Earth and the solar system, including space weather. NASA continues to gain important insight from the HSO, including new observations from the Magnetospheric Multiscale (MMS) Mission, which entered full science mode September 1, 2015. The FY 2017 request supports the continued development of the Solar Probe Plus (SPP) mission, planned for launch in 2018. SPP will fly closer to the Sun than any previous mission to study its outer atmosphere. The request will enable the continued development of critical instruments for the NASA-ESA Solar Orbiter Collaboration mission scheduled for launch in 2018. NASA will continue development of the Ionospheric Connection (ICON) and Global-scale Observations of the Limb and Disk (GOLD) missions. ICON will investigate the interaction of solar forces and Earth's weather systems that drive extreme and unpredicted variability. GOLD will measure densities and temperatures in Earth's thermosphere and ionosphere to improve our understanding and potentially our predictive capabilities of activity in this region.

Aeronautics

NASA's Aeronautics program advances U.S. global leadership by developing and transferring key enabling technologies to make aviation safer, more efficient, and more environmentally friendly. With a request of $790.4 million for Aeronautics, NASA will initiate a bold series of experimental aircraft and systems demonstrations as part of the President's 21st Century Clean Transportation Plan. NASA has laid the groundwork for this initiative through years of research at the component level, through computer modeling, ground tests, and flight tests. In partnership with industry and academia, we have developed technologies and designs that have the very real potential to dramatically reduce fuel consumption, harmful emissions, and noise. NASA is ready to take the next step. With the FY 2017 request we will move out on a plan to develop and fly "X-plane" demonstrators. We will demonstrate and validate transformative concepts and technologies as integrated systems in flight to meet the most challenging needs of aviation. NASA will begin the development of a series of ultra-efficient subsonic transport experimental aircraft, and initiate the detailed design and build of the world's first low boom supersonic flight demonstrator.

NASA's request for Aeronautics also increases investment in developing revolutionary tools and technologies to support X-plane developments, enabling further advances for future transformative vehicle concepts, nurturing university leadership in innovation that will also foster and train the future workforce, and leverages non-aerospace technology advancements.

NASA will continue to advance research and development into the next generation air traffic management system to realize the full vision of Next Generation Air Transportation System (NextGen) NASA will complete a series of major flight tests to demonstrate significantly more efficient arrival and departure operations in full partnership with Federal Aviation Administration (FAA) and industry. NASA will also continue to lead the world for enabling safe UAS operations by developing key technologies that will integrate UAS operations in the National Air Space and realize small UAS operations safely at low altitude operations.

In conclusion, the program of exploration we propose to execute with the FY 2017 request is the envy of the world, and should be a source of pride to the Committee, the Congress, and the American people.

With constancy of purpose and consistent support from the Congress, we look forward to extending human presence into deep space, over the course of the next decade.

Mr. Chairman, I would be pleased to respond to your questions and those of other Members of the Subcommittee.