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Statement of

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

before the

Subcommittee on Space, Science, and Competitiveness
Committee on Commerce, Science, and Transportation
U. S. Senate

Mr. Chairman and Members of the Subcommittee, I am pleased to have this opportunity to discuss NASA's FY 2016 budget request. The President is proposing an FY 2016 budget of $18.5 billion for NASA, building on the significant investments the Administration has made in America's space program over the past six years, enabled through the strong and consistent support by this Committee and the Congress. This request will allow NASA to continue to lead the world in space through a balanced program of exploration, science, technology, and aeronautics research. NASA is an outstanding investment for our nation not only because we uncover new knowledge, but because we raise the bar of human achievement, inspiring the next generation of scientists, engineers and astronauts.

The FY 2016 request includes $4,505.9 million for Exploration with $2,862.9 million for Exploration Systems Development, $1,243.8 million for Commercial Space Flight, and $399.2 million for Exploration Research and Development. This funding, with critical investment from each of NASA's mission directorates, supports NASA's plans to, as the President said in his State of the Union speech, continue our journey to Mars and push "out into the solar system not just to visit, but to stay[.]"
NASA has made tremendous progress on this journey, and we will continue to progress, with building momentum, through the years to come.

As part of our strategic, stepping stone approach to deep-space explorations, NASA is facilitating the development of a U.S. commercial crew transportation capability with the goal of launching NASA astronauts from American soil in the next couple of years. This initiative to facilitate the success of U.S. industry to provide crew transportation to low Earth orbit will end our sole reliance on Russia and ensure that we have safe, reliable and cost-effective access to the ISS and low-Earth orbit. Commercial Products Contracts allowed potential providers to better understand and align with NASA human spaceflight requirements and gave NASA early insight into vehicle designs and approaches. NASA has now entered the development and certification phase with the award of two FAR-based, fixed-price Commercial Crew Transportation Capability (CCtCap) contracts to American companies to transport our Astronauts to and from the ISS. SpaceX and Boeing have laid out milestones with the goal of certified commercial crew capability in 2017. The contractors are committed and at work. Our approach has emphasized competition and redundancy to ensure that NASA's human safety and certification requirements are met, we achieve the best value for the American taxpayer, and we end our sole reliance on Russia for

transportation services. Now, we need the funding necessary to execute this plan to completion. With continued support from the Congress, crews will again launch to the ISS from American soil by 2017.

Technology drives science, exploration and economic opportunity. NASA will continue to maintain a steady pipeline of technology to ensure that we continue to lead the world in space capabilities. NASA's FY 2016 request includes $724.8 million for Space Technology, to conduct rapid development and infusion of transformative space technologies that enable NASA's missions and advance our country's dynamic aerospace industry services. Over the next two years, NASA will execute several in-space demonstrations including: a deep space atomic clock for advanced navigation, green propellant and four small spacecraft demonstrating pioneering new technologies. This summer, NASA plans to again test our Low Density Supersonic Decelerator off the coast of Hawaii to continue proving in flight the new technologies critical for landing larger payloads on the surface of the Red Planet. Informed by the results of FY 2014 testing of solar array and thruster designs, NASA continues development of a high-powered solar electric propulsion capability to enable future exploration missions and meet needs of U.S. aerospace industry. We will continue to progress toward a 2019 demonstration of space-to-ground laser communications, a capability that both American industry and NASA mission teams are eager to explore and harness. But the most exciting piece of our technology investments is the broad portfolio of research grants and other early stage investments, where the new technologies that will change the way we operate in space have a chance to move from ideas to components, to demonstrations of new systems and capabilities. These early stage investments are building stronger links between NASA and academia, and providing unique opportunities for the NASA workforce to innovate.

In December, NASA completed the first orbital test flight of the *Orion* crew vehicle, including a successful high speed reentry through the atmosphere. The Exploration Flight Test 1 (EFT-1) mission of *Orion* was nearly flawless. For the first time in a generation, a deep-space U.S. exploration vehicle has splashed down in the Pacific, and what we are learning from this test gives us increasing confidence in the systems we are designing.

Just as we have recently tested *Orion* by sending it on a shorter version of its future missions, we are continuously testing and experimenting on the International Space Station (ISS) in preparation for long-term missions in deep space. The Administration has committed to extending operation of the International Space Station to at least 2024. The FY 2016 request includes $4,003.7 million for Space Operations, including $3,105.6 million for ISS. Two commercial providers are now under contract to supply cargo to this critical asset, making the extension possible and giving us increasing confidence in our long-term strategy. This month, NASA will launch astronaut Scott Kelly on a one-year mission aboard the ISS to learn more about how to live and work in space for the long term. We will compare his vital signs to those of his twin brother, Mark, here on Earth in a first-ever experiment using identical twins to learn more about the effects of living in space. This is just one example of the vital knowledge and technology that our outpost in space will provide over the coming decade. The Space Station 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.

For the next step on the journey, NASA is developing the required deep-space exploration infrastructure while we plan for the earliest missions. NASA has established Agency Baseline Commitments for the Space Launch System (SLS) and Exploration Ground Systems (EGS), each of which supports a launch capability readiness date for Exploration Mission 1 (EM-1) of November 2018. EM-1 is the first mission for SLS and Orion. NASA remains on schedule for this EM-1 launch readiness date for SLS and EGS. Baseline cost and schedule for *Orion* are now being developed. NASA's budget request provides the funding needed to keep SLS, *Orion*, and EGS on track. NASA will determine the integrated launch date for the EM-1 mission after all critical design reviews are complete, later this year. SLS and *Orion* are

critical to human spaceflight beyond low-Earth orbit as part of an evolvable, sustainable, and affordable exploration program.

The journey to Mars runs through cis-lunar space. NASA's initial deep-space mission will launch to a "Distant Retrograde Orbit" around the Moon. NASA will use this region of space to test and demonstrate operation of human-rated vehicles farther from Earth than ever before. In late 2020, NASA plans to launch an advanced solar electric propulsion based spacecraft to redirect a small asteroid or a boulder from a larger asteroid to lunar orbit. In 2025, launched by SLS, *Orion* will carry a two person crew on a 25-28 day mission to rendezvous with the asteroid in cis-lunar space. Orion will dock with the robotic spacecraft attached to the asteroid in lunar orbit for about five days. NASA's planning leverages development efforts from existing programs across NASA mission directorates, and provides a critical opportunity to exercise our emerging deep space exploration capabilities.

As NASA strives to achieve the dream of sending humans to Mars, it is important to remember we are already there. For 40 years, increasingly advanced robotic explorers have studied the Red Planet. This has dramatically increased our scientific knowledge and helped pave the way for astronauts to travel there. Our latest Mars spacecraft, MAVEN (Mars Atmosphere and Volatile EvolutioN), arrived last September to study the upper atmosphere and joined a fleet of orbiters and rovers on the surface. Next year, we will send the InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) lander to study the planet's deep interior. In 2020, a new rover, building on the incredible success of Curiosity, will help us prepare for the arrival of humans at Mars. The Mars 2020 rover will address the highest priority Mars science objectives recommended by the Planetary Decadal Survey and will carry exploration technology investigations to help plan future human missions.

Mars is a key destination, but only one point on humanity's journey of discovery. Ours is a journey of understanding reaching through our Earth system, across our solar system, and beyond, deep into the universe. The FY 2016 budget request includes $5,288.6 million for Science to continue that mission, with $1,947.3 million for Earth Science, $1,361.2 million for Planetary Science, $709.1 million for Astrophysics, $620.0 million for the James Webb Space Telescope, and $651.0 million for Heliophysics.

NASA's Planetary Science program continues to expand our knowledge of the solar system, with spacecraft in place from the innermost planet to the very edge of our sun's influence. After nine years and three billion miles of travel, the New Horizons spacecraft awakened and began to prepare for its arrival in the Pluto system in July. Right now, Dawn is approaching the dwarf planet Ceres. Juno is speeding toward Jupiter where it will not only send back unprecedented data from a first ever polar orbit of our giant neighbor, but will also demonstrate how solar power can work at great distances from the sun. With the FY 2016 request, NASA will continue development of a robotic asteroid rendezvous and sample return mission, dubbed OSIRIS-REx, planned for launch in 2016. OSIRIS-REx will approach the near-Earth Asteroid Bennu, map the asteroid, and collect a sample for return to Earth in 2023. Looking further to the future, NASA is planning a mission to explore Jupiter's fascinating moon Europa, selecting instruments this spring and moving toward the next phase of our work.

The most important planet we study is the one on which we live -- Earth. Today, 21 NASA-developed research missions orbit Earth and provide a quantitative understanding of our complex planet, its origins and its future. In the last year, we have launched an unprecedented five Earth science missions, starting with the Global Precipitation Measurement Core Observatory (GPM) that already has observed Hurricane Arthur's brush of the East Coast last July. The Soil Moisture Active Passive (SMAP) mission, launched in January, will give us for the first time ever, a picture of soil moisture on a global scale, allowing scientists to monitor droughts and predict flooding caused by severe rainfall or snowmelt. New research missions in formulation include PACE, the Pre-Aerosol, Clouds and ocean Ecosystem continuity mission, that observes ocean color, aerosols, and clouds; NISAR, the NASA-ISRO Synthetic Aperture Radar

mission, being developed in partnership with the Indian Space Research Organization to measure complex processes such as ecosystem disturbances and ice-sheet collapse; and CLARREO, the Climate Absolute Radiance and Refractivity Observatory Pathfinder that will begin pre-formulation this fiscal year.

The Landsat series of satellites is a cornerstone of our Earth observing capability. The world relies on Landsat data to detect and measure land cover/land use change, the health of ecosystems, and water availability. The President's FY 2016 request recognizes Landsat's critical importance and sets out a multi-decadal plan for an Earth-observing architecture that ensures data continuity and reliability. The Sustainable Land Imaging program partnership with the Department of the Interior's U.S. Geological Survey will include flight of a thermal-infrared free flyer and an upgraded Landsat-9 mission, while infusing new technological developments for future missions and ensuring consistency with the existing 42-year Landsat data record.

Twenty-five years ago this April NASA deployed the Hubble Space Telescope. Hubble is still doing amazing science, and the last textbook that will have to be revised because of its discoveries has not yet been written. In just slightly over three years, NASA plans to launch the James Webb Space Telescope (JWST), Hubble's successor, and continue to reveal the unknown with the largest observatory ever put into space. This amazing telescope is taking shape right now in suburban Maryland, where this year the mirrors will be installed on the telescope backplane. The "heart" of the telescope that holds its instruments successfully completed a nearly four-month test in a cryogenic thermal vacuum chamber. NASA's Astrophysics program operating missions include the Hubble, Chandra, Spitzer, and Kepler 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. With the FY 2016 request, NASA will continue development of the Transiting Exoplanet Survey Satellite (TESS). TESS will extend the pioneering work of the Kepler Space Telescope, which showed us that virtually every star in the sky has a planetary system. TESS launches in 2018 and will discover rocky exoplanets orbiting the nearest and brightest stars in the sky in time for Webb to conduct follow-up observations. NASA will also continue pre-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.

Just as the most important planet that we study is the Earth, the most important star that we study is our own. NASA's Heliophysics Program is monitoring the Sun, near-Earth space, and the space environment throughout our solar system, with 29 spacecraft making up 18 missions. These missions work toward one goal: to better understand the sun and its interactions with the Earth and solar system, including space weather. The FY 2016 request supports development of NASA's Solar Probe Plus (SPP) mission, planned for launch in 2018. SPP will be humanity's first voyage to our home star and will repeatedly pass through the Sun's hot outer atmosphere. NASA will also begin science operations of the Magnetospheric Multiscale (MMS) mission to investigate how magnetic fields around Earth connect and disconnect, explosively releasing tremendous amounts of energy in a process called magnetic reconnection.

NASA's Aeronautics research is making air travel cleaner, safer, and more efficient. Every U.S. aircraft and U.S. air traffic control tower has NASA-developed-technology on board. NASA's FY 2016 budget request includes $571.4 million for Aeronautics to fulfill the Agency's strategic research agenda, addressing the most critical challenges facing the aviation sector. NASA is improving safety and reducing development costs of new aviation technologies, developing integrated air traffic management tools to expand airspace capacity with more fuel-efficient flight planning and diminish delays, and researching next generation aircraft configurations, efficient engines, and low carbon propulsion systems such as hybrid electric technology systems. NASA is enabling the future of unmanned and autonomous

flight by providing technical data and analysis to directly inform FAA rulemaking related to Unmanned Aircraft Systems (UAS), funding technology development to address emerging needs for UAS integration, and initiating fundamental research in autonomous systems for aviation. Also in FY16, NASA is initiating a series of flight demonstrations focused on environmental performance, and expanding our portfolio of rapid-turnover feasibility demonstrations to infuse new ideas into our research program. NASA's aeronautics research continues to play a vital leadership role to air travel and commerce by enabling game-changing technologies and innovation that allow the U.S. aviation industry to continue to grow and maintain its global leadership role. NASA is truly with you when you fly.

NASA's spacecraft are voyaging beyond the solar system, we are developing a mission to pass right through the Sun's atmosphere, and our spacecraft are exploring the planets in between. The venerable Hubble Space Telescope is looking back into deep time, Kepler is demonstrating the prevalence of planets around other stars, and the James Webb Space Telescope is on the way. An early version of Orion splashed down in the Pacific, Astronaut Mark Kelly is preparing for a one-year mission in space, and the Space Launch System is on track for a November 2018 launch capability. NASA is embracing its mission as never before. NASA looks forward to working with the Committee and the Congress to make this vision a reality.

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