Statement of
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before the

Subcommittee on Space
Committee on Science, Space and Technology
U.S. House of Representatives

Chairman Palazzo, Ranking Member Edwards and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the status of NASA's Planetary Science program and our missions, both current and planned. NASA's Planetary Science missions continue to explore our solar system in unrivaled scope and depth. NASA spacecraft have visited every planet as well as a variety of small bodies that have much to tell us about the solar system's formation.

Status of Planetary Science Missions

NASA's Planetary Science program is engaged in one of the oldest scientific pursuits: the observation and discovery of our solar system's planetary objects. As noted in NASA's 2014 Science Plan, our strategic objective in planetary science is to ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere. We pursue this goal by seeking answers to fundamental science questions that guide NASA's exploration of the solar system: How did our solar system form and evolve? Is there life beyond Earth? What are the hazards to life on Earth? NASA advances the scientific understanding of the solar system in extraordinary ways, while pushing the limits of spacecraft and robotic engineering design and operations.

Beginning in the inner solar system, NASA's MESSENGER spacecraft has changed our understanding of the planet Mercury. After entering Mercury's orbit in 2011, MESSENGER observations have shown that the planet's surface was shaped by volcanic activity and identified unique landforms molded by the loss of volatile materials. It has also provided compelling support for the long-held hypothesis that Mercury harbors abundant water ice and other volatile materials in its permanently shadowed polar craters. Given the incredible science returns thus far, we look forward to continued discoveries through the end of its mission in March 2015, when the spacecraft will have expended all of its fuel.

Our moon also continues to be a point of study. This past November, the Lunar Atmosphere and Dust Environment Explorer (LADEE) was successfully lowered into its science data collection orbit about the moon, and following the mission's final low-altitude science phase, impacted the surface of the moon, as planned, on April 17. In an incredible race with time, LADEE's Real Time Operations team queued and downloaded all science files just minutes prior to LADEE's impact. Further study of the returned data

will reveal what the instruments saw at these low orbits, just a few kilometers above the surface. Early results suggest that LADEE was low enough to view new things, including increased dust density, with the spacecraft's unique position providing a full scope of the changes and processes occurring within the moon's tenuous atmosphere. A thorough understanding of the characteristics of our nearest celestial neighbor will help researchers understand a great deal about the Earth and other bodies in the solar system, such as large asteroids and the moons of outer planets.

At Mars, we have several missions in operation and in development. The current Mars portfolio includes the *Curiosity* and *Opportunity* rovers, the Mars Reconnaissance Orbiter, the Mars Odyssey orbiter, and our collaboration with the European Space Agency's (ESA) Mars Express orbiter. It also includes the new Mars Atmosphere and Volatile EvolutioN (MAVEN) orbiter, which will arrive at Mars later this month.

Building on the success of the *Curiosity* rover, NASA's Planetary Science program will continue its strategic, multi-mission approach to thoroughly investigating Mars. In a little more than two years on the Red Planet, the mobile Mars Science Laboratory has landed in an ancient river bed, determined the age of the surrounding martian rocks, found evidence the planet could have sustained microbial life, taken the first readings of radiation on the surface, and shown how natural erosion could be used to possibly reveal the building blocks of life protected just under the surface. NASA's *Curiosity* rover is providing vital insight about Mars' past and current environments that will aid plans for future robotic and human missions.

MAVEN will explore the Red Planet's upper atmosphere, ionosphere and interactions with the sun and solar wind. Scientists will use MAVEN data to determine the role that loss of volatiles from the Mars atmosphere to space has played through time, giving insight into the history of Mars' atmosphere and climate, liquid water, and planetary habitability. NASA is also in discussions with the Indian Space Research Organization (ISRO) regarding potential scientific collaboration with their Mars Orbiter Mission (MOM), due to enter Mars orbit about two days after MAVEN. While primarily a technology-demonstration mission, MOM includes five science instruments to study the martian atmosphere, mineralogy and surface features. With multiple data sets being collected, NASA and ISRO scientists will have a wealth of information to help solve mysteries regarding the Mars atmosphere. In addition, NASA and ISRO are talking about setting up a Joint Mars Working Group, under the auspices of the State Department's U.S.-India Civil Space Joint Working Group, that would coordinate our two agencies' plans for studying one of the Earth's nearest neighbors. Finally, both missions will arrive at Mars just in time to join the fleet of Mars-based spacecraft that could witness the effects of comet Siding Spring.

Since the formation of our solar system, comets have been bombarding our inner planets providing water and organic materials necessary for life. From the furthest reaches of our solar system, known as the Oort Cloud, comet Siding Spring has travelled for more than a million years, and for the first time since it was formed, will pass near the sun. Our Mars missions will give us the first opportunity to image and study the nucleus of a comet from

the Oort Cloud region. Comets that we have encountered before have been short period comets (with orbital periods less than 200 years) from the region of our outer planets, not from the more distant Oort Cloud.

Comet Siding Spring will pass within 130,000 km of Mars, blanketing it with the comet's coma and tail. NASA's space observatories and ground-based assets will be studying this event and observing how the martian atmosphere will respond to the interaction with the comet, helping us to learn more about how comets may have seeded our planet with water and the organic material we call the building blocks for life. Using data based on prior observations by the Hubble Space Telescope, the Spitzer Space Telescope, Near Earth Object Wide-field Infrared Survey Explorer (NEOWISE), *Swift* and ground-based telescopes, experts modeled the dust ejected from the comet that could pose a risk to our orbiting Mars spacecraft. It was determined that the risk of affecting the orbital assets is low; however, the spacecraft will adjust their orbits as a precaution, placing them on the other side of Mars during the period of greatest risk.

Future missions to Mars include the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission, which will launch and land in 2016, providing our first look into the deep interior of Mars; participation on ESA's 2016 and 2018 ExoMars missions; and the new NASA Mars rover planned for launch in 2020. The Mars 2020 rover will carry seven carefully selected instruments to conduct unprecedented science and exploration technology investigations on the Red Planet. And, while the Mars 2020 rover is based on *Curiosity's* design, its new, sophisticated instruments will conduct geological assessments of the rover's landing site, determine the potential habitability of the environment and directly search for signs of ancient martian life. For the first time, scientists will use the Mars 2020 rover to identify and select a collection of rock and soil samples that will be stored for potential return to Earth by a future mission. The Mars 2020 rover also will help advance our knowledge of how human explorers could use natural resources available on the surface of the Red Planet. Designers of future human expeditions can use this mission to understand the hazards posed by martian dust and demonstrate technology to process carbon dioxide from the atmosphere to produce oxygen.

With an expected arrival date of March 2015, the Dawn spacecraft is nearing its next target, the dwarf planet Ceres, the largest object in the main asteroid belt between Mars and Jupiter. After completing more than a year in orbit around the asteroid Vesta, Dawn found that Vesta's southern hemisphere boasts one of the highest mountains in the solar system and that striations encircling Vesta and other features point to a giant impact with another body. Once Dawn reaches Ceres it will allow scientists to compare two large asteroids that appear to have dramatically different histories. By studying these two distinct bodies with the same complement of instruments, the Dawn mission hopes to compare the different evolutionary path each took as well as to create a picture of the early solar system. Data returned from the Dawn spacecraft could provide opportunities for significant breakthroughs in our knowledge of how the solar system formed.

Asteroids and other small bodies are important features within our solar system and NASA is currently developing a robotic asteroid rendezvous and sample return mission, dubbed OSIRIS-REx (for Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer), which is planned to launch in 2016. The first U.S. mission of its kind, OSIRIS-REx will approach the near-Near Earth Asteroid 1999 RQ36 (Bennu), map the asteroid, and collect a sample of at least 60 grams for return to Earth in 2023. This mission will help scientists investigate how planets formed and how life began, as well as improve our understanding of asteroids that could impact Earth. The OSIRIS-REx mission will also help prepare and accumulate data for NASA's Asteroid Redirect Mission (ARM) in the areas of remote observation and proximity operations. ARM integrates several building blocks of human space exploration to initiate deep space exploration (our International Space Station experience, Orion and the Space Launch System, Solar Electric Propulsion and other technologies) and contributes significantly to the extension of the human exploration of space beyond Low Earth Orbit (LEO) in an affordable and sustainable way. The crewed mission segment of the ARM will operate a thousand times further than Low Earth Orbit, further from the planet than humans have ever traveled.

NASA leads the world in the detection and characterization of Near Earth Objects (NEOs), and is responsible for the discovery of about 98 percent of all known NEOs. NASA is leading a wide array of activities related to NEOs, including a long-standing ground-based observing campaign, focused flight missions to study both asteroids and comets, as well as conceptual studies and technology development to improve our ability to find NEOs. NASA uses radar techniques to better characterize the orbits, shapes, and sizes of observable NEOs, and funds research activities to better understand their composition and nature. NASA also funds the key reporting and dissemination infrastructure that allows for world-wide follow-up observations of NEOs as well as research related activities, including computer modeling, sample analysis and workshops to disseminate information about NEOs to the larger scientific and engineering community. The cumulative discovery of Near-Earth Asteroids, the largest subset of NEOs, started picking up dramatically in 1998 with the start of NASA's Spaceguard search program and the number of known NEOs has grown from a few hundred to over 11,000 in just 15 years.

NASA enhanced funding for the Near Earth Object survey and characterization activities in support of human exploration and to protect our planet. NASA has expanded our use of ground-based observatories to identify and characterize NEOs of all sizes, including those that are potential targets for the ARM mission. NASA's NEO Observation Program currently funds three survey teams that operate five ground-based telescopes involved in the NEO search effort. Each team conducts independent operations for 14 to 20 nights per month, as weather permits, avoiding approximately a week on either side of the full moon when the sky is too bright to detect these extremely dim objects from the ground. This year, the Wide-field Infrared Survey Explorer was reactivated, renamed NEOWISE and given a new mission to assist NASA's efforts to identify the population of potentially hazardous near-Earth objects (NEOs). While NEOWISE is not designed to discover a large number of NEOs, it will take infrared observations of previously discovered NEOs to produce more accurate size estimates, and to better determine the overall population

size distribution.

At our outer planets, NASA's Cassini spacecraft continues its long reconnaissance of Saturn and its moons, and will do so through 2017, when it will fly a daring mission between the rings and the cloud tops, before finally plunging into the planet. Last summer, NASA's Cassini mission released a natural-color image of Saturn from space, the first in which Saturn, its moons and rings, and Earth, Venus and Mars, are all visible. It is also providing scientists with key clues about Saturn's moon Titan, and in particular, its hydrocarbon lakes and seas. Scientists working with the spacecraft's radar instrument have put together the most detailed multi-image mosaic of the region in Titan's northern hemisphere to date.

Other outer planet missions include the Juno mission to Jupiter and the New Horizons mission to Pluto. Launched in 2011, the Juno mission is on its way to Jupiter with an expected arrival in 2016. During its one-year mission in polar orbit, Juno will draw a detailed picture of Jupiter's magnetic field and find out whether there is a solid core beneath its deep atmosphere. After nine years of travel, in July 2015, the New Horizons spacecraft will flyby Pluto as the first mission to conduct a reconnaissance of Pluto and its moons and will then venture deeper into the distant Kuiper Belt, a relic of solar system formation that comprises many Pluto-like objects. This mission will help us understand worlds at the edge of our solar system and will explore how ice dwarf planets like Pluto have evolved over time.

Additionally, NASA's Planetary Science program includes pre-formulation activities for two potential new missions. In October, NASA plans to release a final Announcement of Opportunity for a new Discovery-class, Principle Investigator led mission, whose destination and science will be identified when selected. Most recently, NASA issued an Announcement of Opportunity (AO) for proposals for science instruments that could be carried aboard a potential future mission to Jupiter's icy moon, Europa. Selected instruments could address fundamental questions about the icy moon and the search for life beyond Earth. With compelling evidence of a liquid water ocean beneath its crust, exploration of Europa is vital to our understanding of the habitability of other planets.

Finally, NASA's commitment to planetary exploration research and analysis (R&A) activities also remains strong and the Planetary Science program continues to lead the world in this area, while ensuring that mission enabling activities are linked to the strategic goals of the agency. Broadly defined, R&A covers the concept studies that provide the science basis for a mission, the necessary technology and techniques for implementing the mission, the calibration, validation, and analysis of data as a mission is underway, and the analysis of archived data after a mission ends. The ultimate goal is to create new knowledge as we explore the Universe, and to use that knowledge for the benefit of all humankind.

One example of this successful strategy is the Solar System Exploration Research Virtual Institute (SSERVI), which is supported by NASA's Science and Human Exploration and Operations Mission Directorates. Recognizing that science and exploration go hand in hand, SSERVI aims to conduct basic and applied research fundamental to lunar and

planetary sciences while advancing human exploration of the solar system. SSERVI research not only includes the Moon but also investigations related to NEOs, the martian moons Phobos and Deimos, and the near space environments of these target bodies. This broad approach encourages collaborative lunar and planetary research, while enabling cross-disciplinary partnerships throughout the science and exploration communities.

Conclusion

NASA 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. For decades, NASA has broadened its reach with increasingly capable missions and has produced a series of exciting achievements in planetary science. With your support, our future missions will continue along this path of exploration, discovery and innovation.

Again, thank you for the opportunity to testify today and your continued support of NASA's Planetary Science program. I look forward to responding to any questions you may have.