

**Statement of
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National Aeronautics and Space Administration
before the
Subcommittee on Space and Aeronautics
Committee on Science, Space and Technology
U.S. House of Representatives**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to discuss the accomplishments, status, and future direction of NASA's Planetary Science program and, in particular, the Mars Exploration Program. NASA's Planetary Science program has produced a long series of visible and exciting triumphs of American science, engineering, and exploration leadership. NASA spacecraft have visited every planet in our solar system, as well as many of the variety of small bodies such as comets and asteroids that have much to tell us about the solar system's formation. So many of our past and current efforts are coming to fruition in the near future that NASA thinks of the period from October 2010 through August 2012—the length of one Martian year—as the Year of the Solar System.

Recent Accomplishments and Current Missions

NASA's current Planetary Science missions in space are returning imagery and data that are revolutionizing our understanding of our solar system's history and its potential habitability—past, present or future.

- Planetary missions Deep Impact and Stardust, whose prime missions were completed, were retargeted to two comet bodies: Hartley 2 and Tempel 1. Surprisingly, Hartley 2 was found to spew basketball and smaller sized snowballs of cometary material. Scientists now recognize that this comet is near its evolutionary end state of completely dissipating into the solar system. By revisiting Tempel 1, we obtained new views of how the comet evolved after its perihelion passage and obtained information on the region previously impacted during the Deep Impact flyby.
- MESSENGER arrived in orbit around Mercury last March. Since then, it has found that Mercury's magnetic field is offset far to the north of its core—a feature we cannot now explain. MESSENGER is exploring surface features scientists are calling “hollows” that indicate they may be actively forming today.
- Launched in September 2011, the GRAIL mission to reveal the structure of the interior of Earth's moon arrives in lunar orbit on New Year's Eve and will conduct its science mission through the first half of 2012.
- Launched in August 2011, the Juno mission to Jupiter is on its way to an 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.

- The Dawn spacecraft is currently in orbit around the asteroid Vesta. There it found that Vesta's southern hemisphere boasts one of the highest mountains in the solar system, three times the height of Mt. Everest. The striations encircling Vesta and other features point to a giant impact with another body. Dawn will depart Vesta in mid-2012 on its journey to Ceres so it can compare these two large asteroids that appear to have dramatically different histories.
- Cassini continues its long reconnaissance of Saturn and its moons, and will do so through 2017. Cassini has observed aurorae and seasonal change on Saturn and Titan its largest moon. It has observed water and organic molecules ejected from geysers on the southern reaches of the small moon Enceladus. And Cassini has found that the giant moon Titan has rain and lakes—not of water but of methane and ethane—making it much like what we believe the early Earth was like.
- The New Horizons spacecraft will flyby Pluto in 2015—the first mission to do so—and will continue into the Kuiper Belt that comprises many Pluto-like objects. In 2010, the spacecraft passed its halfway point.
- OSIRIS-REx will be the next mission in our New Frontier Program, the first U.S. mission to return samples from an asteroid back to Earth.
- The next Discovery mission will be selected from the following candidates: a geophysical monitoring station on Mars; a mission to land a boat in a lake on Titan; and mission to land on a comet multiple times and observe changes as it approaches the Sun.
- At Mars, we have several missions in operation, recently completed, or in development. NASA has long had a strategic, multi-mission approach to thoroughly investigating Mars with a scope, intensity, and duration exceeded only by our study of planet Earth. That is because, beyond Earth, Mars is the most likely and most accessible place to look for signs of life in the solar system. And so we want to study its atmosphere and geology to understand Mars' past, present, and future potential to harbor life.
 - Currently in orbit around Mars are the Mars Reconnaissance Orbiter (MRO) and the Mars Odyssey, which have revealed tantalizing features that appear to have been shaped by water flowing on the surface in the past. We have recently found evidence of briny liquid water flows that disturb the surface of some areas on a seasonally variable basis. MRO imagery was crucial in selecting the landing site for the Mars Science Laboratory.
 - The Mars Exploration Rover Spirit, which ceased operation in March 2011, made the first close-up inspection of water-altered rocks and carbonates. In August, the Mars Exploration Rover Opportunity reached Endeavor Crater. This crater, about the size of the beltway around Washington, DC, contains clay minerals that may hold clues to an ancient, habitable environment in the early, wet Noachian epoch of Mars.
 - The Mars Atmosphere and Volatile Evolution (MAVEN) mission in development for launch in 2013 will help us understand how and why the Martian atmosphere transitioned from the denser, wetter atmosphere of its past to the thinner, dryer one we see today.
 - The Mars 2016 Trace Gas Orbiter, planned as part of the ESA-US ExoMars Mission concept (Mars 2016 and Mars 2018) currently under review, is designed to investigate the seasonally variable concentrations of methane and other gases in the Martian atmosphere and attempts to determine their origins.

Capping this Year of the Solar System, the Mars Science Laboratory (MSL) now sits on top of its Atlas V launch vehicle on its launch pad, with final preparations for launch on track for the opening of the launch window on November 25th. The Mars Science Laboratory rover, named

Curiosity, is the next long stride forward in our scientific exploration of the Martian surface. The Curiosity rover will analyze dozens of samples scooped from the soil, drilled from rocks, and pulled from the atmosphere. MSL is designed to seek to determine the planet's habitability—that is, whether it ever did or whether it could support life. Curiosity's ability to detect and characterize organic compounds, and determine where the "signs of life" might be preserved, will be vital to the selection of instruments and landing site for any other mission involving landing on the Red Planet.

NASA's Planetary Science program over the past decade has been a balanced program of competed missions such as those selected through the Discovery and New Frontiers program, and strategic missions such as Cassini and most of the Mars missions. Mars has warranted special attention because of its potential to answer the broadest range of questions concerning solar system history and habitability.

Planning the Future of Planetary Science – Implementing The Decadal Survey

NASA uses the recommendations of the National Academy of Sciences' Decadal Survey in planning the future of our Planetary Science program in the climate of a constrained Federal budget. Decadal surveys have proven indispensable in establishing a broad national science community consensus on the state of the science, the questions to be addressed, and most importantly, a prioritized list of candidate actions and mission concepts to be pursued or studied over the decade. NASA contracts with the National Academy of Sciences to prepare decadal surveys in all four science areas of NASA's Science Mission Directorate: Astrophysics, Earth Science, Heliophysics, and Planetary Science.

NASA received a new Planetary Science Decadal Survey in March 2011. This survey, *Vision and Voyages for Planetary Science in the Decade 2013–2022* (NRC, 2011), is the product of hundreds of eminent planetary scientists from around the Nation. NASA is extremely grateful to Dr. Steven Squyres for his superb leadership of the Academy committee that authored the Survey report.

The new Planetary Science Decadal Survey has three features that make it an effective guide for NASA and the Nation's planning. First, it recommends a balanced program, and defines what "balanced" means in terms of the relative levels of investment in small, medium, and large (or flagship) missions, technology development, and research & analysis. Second, it defines a priority order for flagship mission concepts, subject to NASA's ability to define mission concepts that fit their expected budget envelope. Third, it defines a set of decision rules to help NASA make decisions under different budget outlook scenarios. This latter feature is proving especially useful, as the budget outlook is less optimistic than the Survey assumed for either their "Recommended Program" or "Cost-constrained Program" options.

The Survey's first recommendation is that:

"NASA's suite of planetary missions for the decade 2012-2022 should consist of a balanced mix of Discovery, New Frontiers, and Flagship missions, enabling both a steady stream of new discoveries and the capability to address larger challenges like sample return missions and outer planet exploration."

The Survey also identified "the need to maintain programmatic balance by assuring that no one mission takes up too large a fraction of the planetary budget at any given time." NASA is

planning its Planetary Science portfolio accordingly and using the Planetary Science Subcommittee of the NASA Advisory Council for guidance and feedback on our specific implementation plans.

The Survey's highest priority flagship mission is a Mars sample-caching mission. The Survey identified this as the highest priority flagship if three conditions pertain: 1) it is to begin the NASA-European Space Agency Mars Sample Return campaign; 2) NASA must be able to implement its portion of the mission at a cost to NASA of no more than approximately \$2.5 billion; and, 3) the mission must be launched by 2018. NASA is working with ESA to define a mission that meets these criteria and can be accommodated within anticipated resources.

Following the Mars sample-caching mission, the next highest priority flagship mission is the Jupiter Europa Orbiter. Europa and Mars Sample Return were both in the prior Decadal Survey (from 2002), and, thus, NASA has a long history of studying Europa mission concepts. Here again, NASA had been coordinating with ESA on these studies and, prior to the recent Decadal Survey, had been studying a joint two-satellite Jupiter System Mission. Given the cost of the Europa mission, estimated by the Survey at \$4.7 billion, the Survey recommended that:

“NASA should immediately undertake an effort to find major cost reductions for JEO, with the goal of minimizing the size of the budget increase necessary to enable the mission.”

NASA is currently conducting such a study with this objective. The third priority flagship mission in the Survey is a Uranus Orbiter and Probe mission. Rounding out the Survey's list of flagship candidates are an Enceladus Orbiter and a Venus Climate Mission.

The Decadal Survey also recommended that NASA continue to allow Discovery missions to be proposed to Mars. In fact, NASA is currently supporting development of a mission concept for a Mars geophysical monitoring station as one of three in competition to be the next Discovery mission. This mission would collect data on the interior of Mars. Other than the Earth and to a lesser extent the Moon, there have been no surface-based observations of the interior of terrestrial planetary bodies.

Potential Mars Mission Under Consideration

NASA is studying the Mars sample-caching mission for launch in 2018 and also the Mars 2016 Trace Gas Orbiter (TGO) in concert with ESA. NASA and ESA have been working on this since 2007. As a basis for these discussions, in November 2009, the NASA Administrator and the Director General of ESA signed a Statement of Intent for Potential Joint Exploration of Mars *“to consider the establishment of a joint initiative to define and implement their scientific, programmatic, and technological goals for the exploration of Mars. Initially focusing on 2016 and 2018, this initiative would span several launch opportunities with landers and orbiters...”*

As currently envisaged, the Mars 2016 and 2018 missions are linked since the 2016 mission is an orbiter that would not only perform atmospheric trace gas science but also provide the space telecommunications relay services to enable communication between mission controllers on Earth and the 2018 rover-cacher. In July 2010, NASA and ESA selected science instruments for the 2016 TGO mission from a joint Announcement of Opportunity. In June 2011, NASA and ESA agreed to explore a single rover for the 2018 mission to accomplish both our science and technology goals. The 2018 mission to put a cacher-rover on the surface of Mars would take

advantage of the best energetics (the energy required to transfer mass from the Earth to Mars) in a decade and a half.

Due to increasing budget pressures associated with the nation's fiscal challenges, in June 2011 NASA requested ESA's support for a review of the potential joint Mars program in an effort to maximize available resources, while continuing to meet key scientific and technical requirements of both Agencies. This joint review is currently underway. As part of the ongoing technical review, ESA recently invited the Russian Space Agency, Roscosmos, to consider potential participation in the Mars 2016 and Mars 2018 missions. Russia has yet to formally respond to this invitation.

NASA has had a long and productive history of successful cooperation with ESA, particularly in the area of space science. This relationship has spanned decades. Last month Administrator Bolden and the ESA Director General Dordain met to discuss among other topics the progress of the ongoing Mars exploration program review. At that time they both reaffirmed their Agencies' commitment to explore cooperation on a mutually beneficial Mars exploration program.

Summary

We are in an era of scientific revolution in our understanding of the solar system. The new Planetary Decadal Survey recognizes this scientific revolution and charts an exciting and compelling way forward. To summarize according to the questions posed in your letter of invitation to testify:

1) NASA is studying the implementation of the Mars 2016 and Mars 2018 missions with ESA within available budgetary resources. The Mars 2018 mission would satisfy the objectives of the mission identified by the Decadal Survey as the highest priority flagship mission for the coming decade, subject to the conditions identified above and to funding availability. And it would be the first step towards returning a sample from Mars, which has long been a goal of our larger Mars and planetary exploration strategy.

2) NASA is pursuing a strategic continuum of flyby, orbit, land, rove, and return samples. Ultimately, we plan to return samples from the surface of Mars, both for their scientific value and for the information they will provide in support of what will ultimately be human exploration of the Red Planet. MSL is an integral part of this long-range strategy, both for the entry, descent, landing, and roving technologies it enables and for the scientific contribution it will make to the question of Mars' past and present habitability.

3) NASA and the scientific community have no shortage of compelling and innovative ideas for a robust planetary exploration program, but the fact is that we are in very challenging fiscal times, which requires focus, partnerships, and the development of innovative approaches to reduce the costs of these exciting missions. The Decadal Survey was aware of these constraints and provided multiple concepts for potential flagships, depending on the funding available. Of the recommended flagship missions, we are currently focusing on the Decadal Survey's highest-priority – Mars sample caching – while simultaneously seeking new ways of pursuing the other compelling missions such that they can be realized within the constrained budgets we face. For example, NASA also is currently studying a Jupiter Europa Mission, the Survey's second priority flagship mission. The Survey's third priority flagship mission is a Uranus Orbiter and Probes mission.

NASA's plans for addressing the Planetary Science Decadal Survey recommendations will be detailed as part of the President's FY 2013 budget request. This is also the time frame in which NASA and ESA will need to have our plans firmly in place in order to implement any proposed Mars 2016 and Mars 2018 missions.

Mr. Chairman and Members of the Subcommittee, I appreciate your continued support of NASA's Planetary Science program. I would be pleased to respond to any questions you or the other Members of the Subcommittee may have.