Statement by
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before the

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

10 September 2014

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the future of one of our nation’s crown jewels: NASA’s planetary science and solar system exploration program. My name is Jim Bell. I’m a Professor in the School of Earth and Space Exploration at Arizona State University and a planetary scientist involved in a number of NASA robotic planetary exploration missions, including the Opportunity and Curiosity rovers and the upcoming Mars-2020 rover.

I also serve as President of The Planetary Society, the world's largest public space advocacy organization, where today I am representing more than 45,000 current members, and more than half a million people total from around the world who have been members since we were founded in 1980. Our membership is comprised of individuals who are excited, inquisitive, and inspired by the bold missions that explore our solar system and beyond. We are a nonprofit, independent organization that seeks to know the Cosmos and our place within it. We work to empower citizens to advance space science and exploration. Promoting planetary exploration by NASA and other space agencies is one of the core goals of our organization.

Our members respond to planetary exploration for the same reasons much of the public does: it tackles some of the most fundamental questions we ask ourselves. Where did we come from? Are we alone? How common is life and can it take hold in places other than Earth?

The wonderful thing about planetary science is that we, the science and space community, have the power to attempt to answer these questions directly. We can build a spacecraft to search for hints of life on Jupiter’s ocean moon, Europa. We can robotically grab samples from some of the solar system’s oldest bodies—asteroids—and return them to Earth for analysis. We can drill into the ancient surface of Mars for clues to the past habitability of the red planet. We can send missions to Uranus or Neptune to better understand the enigmatic (and possibly similar) exoplanets discovered by the Kepler Space Telescope. For the first time in human history, our ambition is no longer bounded by limits in technology, but by self-imposed limitations on resources.

In the past half century, we have witnessed a revolution in our understanding of our planetary neighbors. This revolution has been motivated by human curiosity, by the urge to explore, and by the need to pursue answers to fundamental questions about our origins. And it was fueled by modest funding levels that never peaked at more than 12% of NASA's entire budget.

Robotic planetary exploration also provides crucial data and initial reconnaissance that support future human exploration. NASA followed this path during the 1960s, and is doing so again with its Mars and asteroids missions.

But, as I will discuss, the future of planetary exploration—and the ability to answer the compelling, fundamental questions mentioned above—has been severely undermined by disproportionate cuts initiated by the Administration in recent years. These cuts have dramatically reduced NASA's ability to explore the solar system, and have forced the United States into a unilateral retreat from both the outer and inner solar system. The near-term effects of this retreat can no longer be prevented, but a supportive Congress and a receptive White House can minimize its impact with a small adjustment in funding beginning next fiscal year.

In your invitation letter, you asked me to address the issues facing the planetary science community, NASA's proposed budget for planetary science, ways to encourage the development of deeper partnerships between space science and industry, as well as to provide commentary on the American Space Technology for Exploring Resource Opportunities In Deep Space (ASTEROIDS) Act.

I will begin by sharing The Planetary Society's concerns about funding levels at NASA for Planetary Science.

There are two important points to keep in mind when discussing the health of the planetary science program:

1. **Discoveries in planetary science depend on planetary exploration missions.** Missions are the lifeblood of the field. They directly measure a variety of phenomena that cannot be detected by Earth- or space-based telescopes or simulated in laboratories or computers, providing crucial data that cannot be gathered any other way. Without missions, new science is severely limited.
2. **Today's funding pays for tomorrow's missions.** Long lead times are required to plan, design, build, and launch planetary spacecraft, and the vast majority of their cost is incurred during these development stages. Current missions, or those about to launch, have already been paid for by significant previous investments. Cuts made today won't manifest themselves until years later.

With this in mind, we see that the impressive list of missions currently exploring our solar system from Mercury to Pluto and beyond is the result of strong funding from the previous decade. Looking at the period covered by the first National Academy of Sciences Planetary Decadal Survey (2003 – 2012), NASA's Planetary Science Division was funded at an average of $1.53 billion per year, adjusted for inflation.

Starting with its FY2013 budget request, the Administration began to levy disproportionate cuts on NASA's Planetary Science Division, initially proposing a 21% cut and pulling out of a joint Mars exploration mission with the European Space Agency. The Administration has continued to target planetary science in its FY2014 and FY2015 budget requests, despite Congressional resistance, with funding hovering around $230 million below the previous decade's average.

At the same time, NASA's Planetary Science Division has had to take on additional programmatic responsibilities. The crucial need for Plutonium-238 as an energy source in spacecraft drove NASA's Planetary Science Division to pay the Department of Energy (DOE) to restart production of this crucial isotope. And beginning in FY2014, the DOE's Radioisotope Power Systems infrastructure costs were also shifted to the planetary program. This works out to around $70 million per year to pay the DOE for services they had provided to NASA since the 1960s.

The Planetary Society is not arguing about who should pay for this important program. Plutonium-238 fuel is a requirement for planetary exploration and restarting production is one of the great success stories in modern space policy, but this must be acknowledged as a drain on already diminished resources.

The other issue is an increased number of operating missions. Now, this is a good problem to have, but the twelve currently-active missions combined consume hundreds of millions of dollars within the planetary budget. Many missions are already operating at severely scaled back levels and have sacrificed science to preserve continued operations.

These two developments have exacerbated the disproportionate cuts to NASA's Planetary Science Division, and we have already seen mission opportunities delayed and cancelled. The number of missions in development are dwindling [see Figure 1], reaching near-record lows by the end of this decade. In 2017, both the Cassini mission to Saturn and the Juno mission to Jupiter will reach their end, and NASA will "fade to black" in the outer solar system for the first time since the early 1970s[1]. The end of MESSENGER at Mercury in 2015 will cause a similar fade to black in the inner solar system. NASA has no official plans to return to either area of our solar system, though the Europa Clipper mission is a possible opportunity being discussed for an outer planets mission.

The current Decadal Survey, the National Academy's *Visions and Voyages for Planetary Science 2013 – 2022,* recommended a balanced planetary exploration program of small, medium, and flagship missions, with stable research funding and technology development. NASA's Planetary Science Division has done an admirable job in tough budgetary circumstances, and some priorities are being met—like the caching capability built into the Mars-2020 rover—but fundamentally, the budgets requested by the Administration since FY2013, as well as the increased programmatic commitments on the Planetary Science Division, do not support the recommended program by the Decadal Survey.

[1] U.S. Planetary Science: Fading to Black, Hinners and Braun, Space News, April 22, 2013 – Attached.

The Planetary Society believes strongly that planetary exploration is a crucial program in a balanced NASA. The United States has invested billions over the decades to develop unprecedented capabilities in deep space exploration. There are fundamental questions that the scientific community can attempt to answer. And robotic exploration itself is a modest budget line within NASA, rarely approaching even 1/10th of the agency’s total budget. Planetary science, along with NASA science programs in general, have clear, achievable, accepted goals defined by the Decadal Survey, and the potential to further revolutionize our understanding of the Universe around us.

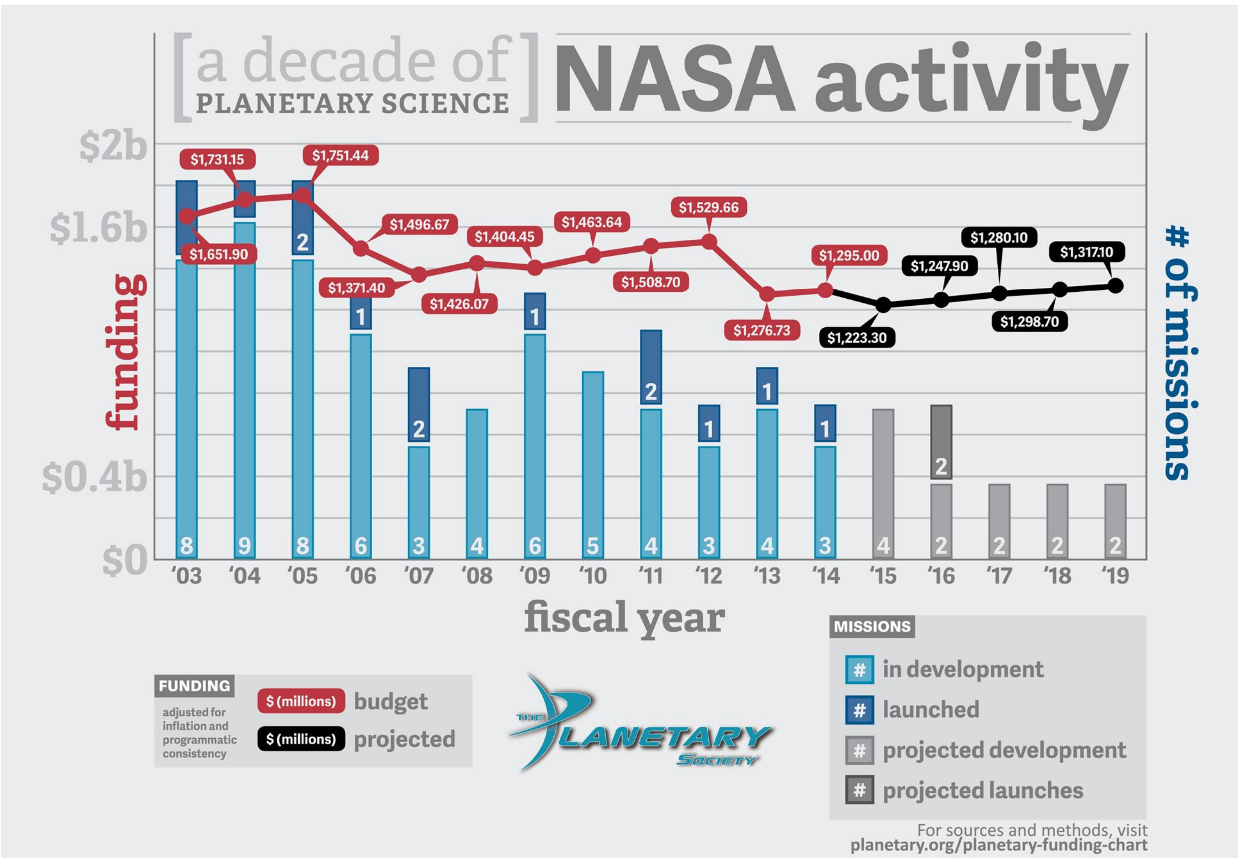

Figure 1. Funding level of NASA’s Planetary Science Division from FY2003 – FY2019, in Real Year Dollars (adjusted for inflation) and displaying the number of missions in development according to NASA Budget requests during this period. The average budget for the Planetary Science Division from 2003 to 2013 was $1.53 billion per year. Note that by the end of this decade the NASA Planetary Science Division will be working on only two new missions (Mars 2020 and Discovery 13) while maintaining a diminishing set of aging spacecraft. The Administration has said it intends to begin Discovery 14 during this period, but no timeline is presented within the FY2015 President’s Budget Request and thus not included here. Raw data and methods are available at http://planetary.org/planetary-funding-chart. Credit: Lori Dajose/Casey Dreier for The Planetary Society.

Fortunately, Congress, and this Subcommittee in particular, have strongly supported NASA’s Planetary Science Division, and on behalf of the membership of The Planetary Society, we thank you for this. The 2014 NASA Authorization bill (H.R. 4412) passed by the House and drafted in this committee includes a clear policy provision (Section 321) supporting the Decadal Survey’s recommended cadence of Discovery and New Frontiers missions, as well as a new flagship mission to Europa in the early 2020s. We strongly support this language in H.R. 4412, and thank you again for this support.

What are some of the ways in which The Planetary Society is contributing to upcoming planetary science missions, including Mars-2020 and a potential science mission to Europa?

The Planetary Society has a long history of official and unofficial contributions to a wide range of planetary science missions.

Since the early 1980s, weôve held large public gatherings to support major planetary mission milestones. These ñPlanetfestsò typically host thousands of people and have celebrated Voyager 2ôs encounters with the outer planets, every modern Mars landing, and the asteroid impact of the Deep Impact mission.

The Society also offers the most in-depth coverage of NASAôs science missions on our website, radio show/podcast, and magazine. Our website and radio show are provided free, without advertisements, for members and non-members alike. The Society has also helped to foster an entirely new online community of amateur enthusiasts who work directly with the raw image data from NASA spacecraft.

Our members funded the construction of the first private instrument to fly on a NASA mission: a microphone on the ill-fated Mars Polar Lander. And getting a microphone on Mars (at no cost to the taxpayer) is one of our long-term goals and provides an added dimension to the mission.

The Planetary Society is the official outreach partner for the Mastcam-Z camera system on the Mars-2020 rover, and The Society plans to make a serious, long-term investment in building awareness with the public and finding a variety of ways in which they can become involved with the images from the next rover. And while The Society as yet has no official connections to the potential Europa mission, we will vocally support and promote that mission, if it is pursued.

The OSIRIS-REx mission launches in 2016 to the asteroid Bennu, where it will grab a sample of the asteroidôs surface and return it to Earth. The name, Bennu, was the winning entry in a naming contest we ran here at the Society. Weôve also collected over 350,000 names and messages from around the world that will ride along with the spacecraft.

The Society has also maintained a strong relationship with the New Horizons mission team. We worked with them to create a digital time capsule that will be opened when the spacecraft flies by Pluto next year.

The Society actively promotes planetary science and space science in other ways, too. Our members donate the funds to support exoplanet observations of the Alpha Centauri system with a team from Yale. We engage with industry and help fund development of low-cost technological solutions for sampling the surfaces of other worlds. We also funded the effort that solved the so-called ñPioneer Anomalyò which was the unexpected deceleration of the Pioneer 10 and 11 spacecraft as they left our solar system.

All of these projects I just mentioned are paid for by donations from our membership. It's one thing to say that the public is interested in planetary science, and another to see people support these efforts with their hard-earned cash. They've voted with their dollars.

How is The Planetary Society encouraging the development of partnerships between science and industry?

The Planetary Society funds and carries out a number of science and technology projects that advance the development of technologies for future missions. We've worked with Honeybee Robotics to develop a simple sample acquisition hardware system that could fly on Discovery-class missions, have explored novel ways to deflect asteroids using lasers, and we are demonstrating solar sail propulsion for small spacecraft with our LightSail cubesat mission.

The Planetary Society, in its role as a nonprofit organization, has built and implemented partnerships with science institutions, government organizations, and private industry. Some of our science and technology projects such as our solar sail mission and our Living Interplanetary Flight Experiment (LIFE) have involved building teams of universities, private science entities, private industry, and NASA. In these activities, The Planetary Society connects scientists, engineers, and manufacturers, while also reporting to and engaging the public about our exciting projects and partnerships.

It is especially important to me personally that the Society engages the exciting "New Space" sector of the industry. In my role as a Professor at ASU, I interact with young engineers and scientists every day, and I witness their enthusiasm and excitement about the work being done by brash startups like SpaceX, Virgin Galactic, Bigelow Aerospace, Planetary Resources, and others. In fact, we've started a new program at ASU, the Space Technology and Science ("NewSpace") Initiative, that is designed to help directly connect the many ASU students, faculty, and staff across campus doing space science and engineering, with the goals and needs of these kinds of new space-related startup companies. As the Director of this Initiative at ASU, I am delighted to see NASA strongly support both large- and small-scale commercial space development activities across the nation, and as a working planetary scientist and President of The Planetary Society I am eager to see these new companies help to enable a wide range of exciting new solar system research and exploration opportunities.

What are your perspectives on the potential extraction of resources from asteroids? Provide feedback on H.R. 5063, the American Space Technology for Exploring Resource Opportunities In Deep Space (ASTEROIDS) Act.

Asteroids are the ancient leftover building blocks from which all of the planets were made. Early in the history of our solar system, they may have delivered some of the elements of life to our planet and others. A few of them also pose collision threats to our home world. By finding them and studying them, with telescopes, with space missions, or in laboratories when we study meteorites (some of which are tiny pieces of asteroids) we have begun to understand the details of how our planet and others formed and changed over time. Was Earth's water brought here by a steady rain of water-rich asteroids and comets early in the solar system's history? How did impacts by large asteroids influence the development of life on our home planet? Which asteroids out there represent future potential impact hazards? These questions are on the frontier of current planetary science research, and are among the kinds of asteroid-related studies recommended by the Decadal Survey. NASA's programs to answer these questions deserve full support.

The issue of resources on asteroids is particularly compelling, not only from the scientific perspective noted above, but also as we begin to imagine a future where humanity is moving outward beyond our home world, exploring and settling new frontiers in our solar system. Just like many of the settlers who moved to the American West in the 19th century, settlers moving outward from Earth in the 21st century and beyond will want to try to figure out how to "live off the land" as much as possible. Based on what we know now, there's good reason to believe that asteroids could provide many of the raw natural resources that humans will need to live and work beyond Earth. Some are water-bearing (and thus, oxygen-bearing), others have significant concentrations of metals and silicates useful as building materials. Based on meteorite studies, some are even likely to contain significant amounts of precious metals. All of these attributes make asteroids potentially economically attractive targets for future resource extraction.

While the extraction of space-based resources from asteroids is certainly still many years away, The Planetary Society believes that it would be wise to start making the required investments in technology, infrastructure, and transportation systems required to study asteroids in the level of detail needed to make truly informed future decisions about their individual resource potential. As such, we support investments, through both commercial and governmental programs, in the kinds of technologies needed for the exploration and utilization of asteroids as contemplated in H.R. 5063. Likewise, commercial and/or government investment in cataloging, characterizing, and mapping asteroids will enhance our ability to understand their potential for resource extraction as well for their potential as Earth-colliding objects. Investment to map and characterize asteroids should receive high priority, with an emphasis on identifying those near-Earth asteroids that could pose a collision threat.

The Society recognizes that a policy regarding property rights for resources mined from asteroids will eventually be important for commercial investment, but we believe that, since this is an area of current controversy among specialists, it is premature for us to take a position in support of the perspective on the property rights issues covered in the bill. Rather, we advise careful thought and deliberation before moving forward in this area, and embrace H.R. 5063's call to develop the frameworks necessary to attract commercial investment.

Closing remarks

Around midnight on August 6th, 2012, thousands of people gathered in Times Square to witness something that had never happened before (Figure 2). They were there to see the Curiosity rover attempt its landing on Mars, which was broadcast live on the Jumbotron. Pictures from that night capture the excitement, awe, and joy that the crowd experienced during the roverõs seven minutes of terror as it landed on the red planet. This wasnõt a scientific momentô though it would lead to great science; it was a human one. In that instant, the hopes of a nation were with a robotic spacecraft built by our best engineers and funded by the taxpayers to pursue a peaceful mission to uncover the secrets of another planet. Curiosity remains one of NASAõs most popular missions, human or otherwise.

Figure 2. A couple among a crowd of thousands in Times Square listens to updates on the Curiosity roverõs landing attempt. August 6th, 2012. Photo credit: Navid Baraty.

NASA is the most active, most capable, and most successful of all of the worldõs space agencies. As such, when NASA doesnõt prioritize planetary science, no other agencies are presently capable of filling the gap. Other space agencies around the world are catching up, however. Europe and Russia have established planetary exploration programs with ambitious ongoing or near-term missions planned. China is building on its recent mission successes and rapidly advancing plans to explore beyond the Moon with robotic spacecraft. And even as I speak, Indiaõs first Mars orbiter is nearing the red planet.

The major NASA achievements in planetary exploration slated for the near futureô the Curiosity rover arriving at Mt. Sharp, the new MAVEN orbiter arriving at Mars, the New Horizons flyby of Pluto and its moons, the Dawn mission going into orbit around the largest asteroid, Ceresô represent the best of space exploration. They are bold feats of engineering and scientific prowess. They are tangible manifestations of blatant optimism in the face of great odds, each one having faced immense challenges that were overcome by careful planning and outstanding

American engineering. They engage the public with their daring feats of discovery. And yet, planetary science is unique within NASA in having its budget cut dramatically despite its clear scientific and public successes.

Spacecraft take time to design, build, and fly. Our current set of missions were all initiatives begun during previous Presidential administrations. The future missions called for by the Decadal Survey need investment now, but they are not receiving it.

NASA already faces its biggest gap in solar system exploration in decades. But wise action by the Congress and the Administration can rejuvenate planetary science by supporting Decadal recommendations for a balanced mission portfolio. It is a worthy investmentð $1.5 billion per year, less than 9% of NASAôs total budgetð to maintain a peerless program of exploration that inspires the country, reveals the mysteries of our solar system as well as our home planet, and searches for hidden abodes of life in the worlds around us.

On behalf of the members of The Planetary Society, I would like to again thank the Members of the Subcommittee, and of the Congress in general, for their solid support of Americaôs planetary science exploration program over the past several years. I would also like to thank you personally for the opportunity to address you all today, and to share my own thoughts on the importance of NASAôs planetary exploration program for the nation, and for the world.

APPENDIX.
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Space News

U.S. Planetary Science: Fading to Black

By Robert D. Braun, Noel W. Hinners | Apr. 22, 2013

By any objective measure, planetary science is one of Americaôs crown jewels. A unique symbol of our countryôs technological leadership and pioneering spirit, this endeavor has consistently demonstrated that the United States is a bold and curious nation interested in discovering and exploring the richness of worlds beyond our own. In addition to informing our worldview, these missions are inspirational beacons, pulling young people into educational and career paths aligned with science, technology, engineering and mathematics, the foundation of continued U.S. economic competitiveness.

Beginning with the flight of Mariner 2 more than 50 years ago, the United States has consistently led the robotic exploration of our solar system. Decade by decade, we have created, flown and operated a balanced portfolio of missions to explore destinations across the solar system. For example, in the 1970s, the U.S. conducted the Viking missions at Mars, the Pioneer missions at Venus, and the Voyager and Pioneer missions to the outer planets. In the 1990s, the U.S. carried out multiple missions at Mars, Cassini to Saturn, as well as missions to our Moon, the asteroids and a comet. Today, U.S. spacecraft are en route to Jupiter and Pluto, two rovers trundle across the martian surface, and orbiters at Mars and Saturn are returning tantalizing insights.

Despite the success that has built up over decades, today we are on a path that relinquishes U.S. planetary science leadership. Starting in 2017, with the end of the Juno mission at Jupiter and the Cassini mission at Saturn, NASA will only have spacecraft at or on their way to one planet: Mars. Most striking is that after four decades of U.S. spacecraft operating in the vast outer solar system, there are currently no outer planet missions of any kind planned until after 2030 ð when the European Jupiter Icy Moons Explorer is scheduled to arrive at its destination. In 2017, our insight into much of the solar system will go dark. Because it takes at least five years to conceive, design and implement a planetary science mission, this cliff is not only upon us, it is getting larger with each passing day. The next suite of planetary science missions should already be in development.

The emergence of the Chinese and Indian space programs and the continued successes of the European and Japanese programs illustrate that robotic exploration of space is an international priority ð a way to gain scientific knowledge, global prestige and advance technological capability. In the coming decade, China is preparing a series of robotic lunar missions, Russia is preparing lunar, Venus and Mars missions, India has plans to go to the Moon and Mars, Japan is planning a second asteroid sample-return mission, and the Europeans are headed to Mercury, Mars, the asteroids and Jupiter.

Unfortunately, President Barack Obamaӳ 2014 budget request for NASA continues the draconian path for planetary science laid out in the administrationӳ 2013 request. Most striking, this budget line is reduced approximately $200 million relative to the 2013 level appropriated by Congress and signed into law by the president just three weeks ago. While a series of Mars missions is scheduled through 2020, NASA remains without plans for the development of missions to any other planets. Does the U.S. really want to cede leadership of the scientific exploration of the rest of the solar system to other nations?

Mars exploration can tell us much about our past and our potential future, but we have learned that our solar system and other planetary systems are exceedingly diverse. From the subsurface ocean of Jupiterӳ moon Europa to the vast hydrocarbon season Saturnӳ moon Titan to the mysterious ice giants Uranus and Neptune that stand like sentinels at the solar systemӳ edge, there is much yet to discover in our cosmic backyard. A year ago, the National Academies put forward a roadmap for solar system science in the 2013-2022 decade. Balance was sought, both in the destination of the U.S. science missions and in their scope, to enable a steady stream of new discoveries and the capability to address grand challenges like sample return and outer planet exploration. However, driven by budget shortfalls and its own penchant for large, expensive missions, NASA has abandoned this balanced approach, resulting in a complete shutdown of missions to planets other than Mars after 2017.

For 50 years, NASAӳ program of robotic planetary science has been unparalleled in its successes and scope. Continuing this success requires action now, as these missions take years to develop and then to reach their destinations. We can continue U.S. leadership in this field or we can abandon an endeavor that inspires our children, builds the scientific and engineering literacy of our country, and increases our economic and technological competitiveness. Now is not the time to curtail the pace and scope of our planetary science program. This is a pursuit worthy of a great nation.

Robert D. Braun is the David and Andrew Lewis Professor of Space Technology at the Georgia Institute of Technology and served as NASA chief technologist in 2010 and 2011. Noel W. Hinners retired as vice president of flight systems for Lockheed Martin Space Systems and formerly served as associate deputy administrator and chief scientist of NASA, director of the NASA Goddard Space Flight Center, and NASA associate administrator of space science.