

THE PLANETARY REPORT

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A PEAK YEAR

2016 YEAR IN PICTURES



TOP LEFT A special evening reception and fundraiser opened The Planetary Society's 35th Anniversary celebrations on October 23, 2015. At Pasadena's famed Huntington Library, cofounder Louis D. Friedman told stories about The Planetary Society's inception and early days to our charter members, friends, and associates.

TOP RIGHT Naïla Erwin enjoyed the festivities and connected with other members, sharing ideas for joining ranks to help further the Society's mission.

BOTTOM For the perusal of reception attendees, the Huntington Library assembled a sampling of letters, photos, and memorabilia from The Planetary Society's beginnings in glass museum cases.

Calling All Charter Members Envisioning a New Outreach Program

A **PLANETARY SOCIETY** charter member is a person whose membership began in 1980 or 1981 and who remains active today. We charter members have a long-term perspective about The Planetary Society and the importance of its ongoing goals and plans, and we can be a power base of talent, ability, and ideas for the Society. However, there has not been a format for us to organize and work together on projects for The Planetary Society.

At the Society's 35th Anniversary celebrations in Pasadena last year, several of us charter members got acquainted and our conversations almost always led to our remembrances from the early days. Even then, we sensed that we were part of something that was going to be important. Most of us still have our charter Member certificates, our certificate of appreciation, early volumes of *The Planetary Report*, and programs, photos, and patches from early events such as the 20th Anniversary of Interplanetary Flight Commemoration in December 1982. We wondered if some of these personal items could be donated to The Planetary Society's archives. We talked about ideas for helping with special fund-and membership-raising events, going out to schools to talk about The Planetary Society, and about topics such as *LightSail*, the Search for Extraterrestrial Intelligence (SETI), and exoplanets. We were full of ideas, but unsure of how to proceed.

I contacted Robin Young, the Society's donor relations coordinator, and we began an e-mail dialog that led to a conference call between Robin, Society Chief Development Officer Richard Chute, and myself. We brainstormed on potential ways in which charter members, working together under the direction and guidance of a Planetary Society staff member, could make a wide variety of important contributions.

The concept is nebulous at this point, but we would like to know whether the general idea of a task force of charter members working together on a project appeals to you. If so, please e-mail robin.young@planetary.org or richard.chute@planetary.org with your ideas and suggestions. We'll see what kind of response we get and keep you informed.

—Naïla Erwin, Charter Member 882

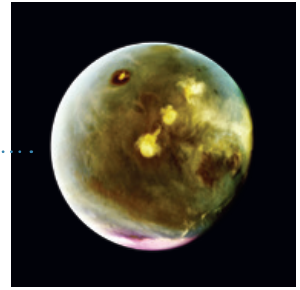
Are you a charter member who would like to be more involved? We encourage you to consider Naïla's invitation to explore possible ways to increase engagement with our most loyal supporters and to expand ways of achieving our mission of empowering the world's citizens to advance space science and exploration! 🚀

—Richard Chute, Chief Development Officer

To read more about the archives project made possible by the generosity of our charter members, see page 16.

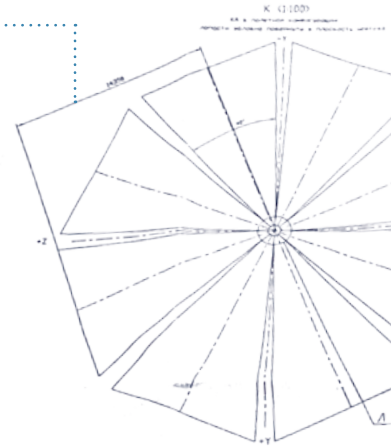
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ON THE COVER: Jupiter's north and south poles bookend this issue of *The Planetary Report*, courtesy of *Juno*. Storm systems and weather unlike anything encountered in the solar system are visible in this color-enhanced view of the gas giant's north pole. Much like Earthly hurricanes, some of these storms have a pinwheel shape. *Juno's* tracking of these features over many orbits will enhance our understanding of Jupiter's atmospheric dynamics. *Image: NASA/JPL/SwRI/MSSS*

CONTACT US
The Planetary Society
60 South Los Robles Avenue
Pasadena, CA 91101-2016
General Calls: 626-793-5100
E-mail: tps@planetary.org
Internet: planetary.org

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Art Director LOREN A. ROBERTS for HEARKEN CREATIVE
Copy Editors AXN ASSOCIATES & KARL STULL
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BILL NYE is chief executive officer of The Planetary Society.

A Steady Pace Wins, Losses, and Forging Ahead

WITH A NEW U.S. PRESIDENT and administration, we can expect some big changes in United States space policy. I am happy to report that your Planetary Society is in a good position to help maintain a steady pace of exploration. For the last few years, we've increased our focus on political advocacy, and we've done so with the importance of trust and relationships in mind. We will continue to fight for funding of planetary mission teams and spacecraft.

In October, the Society celebrated a fight hard-fought and won when we presented Alan Stern and the *New Horizons* mission team with *The Cosmos Award for Outstanding Public Presentation of Science*. Alan and his team brought Pluto down to Earth. They engaged the public through social media on a scale never before seen. The *New Horizons* spacecraft continues to amaze, transmitting images and scientific data of this intriguing and extraordinarily far-off world. I know many of you, as Planetary Society members, have been supporting this mission for more than two decades. As we tell you often, we appreciate it. And I want you to know that Alan really appreciates it. As he delivered his acceptance speech, he thanked The Planetary Society for our long history of public outreach and for our Pluto mission support and advocacy in Washington, D.C. He was clearly moved, and his descriptions of the team's hard work and the mission's accomplishments so far were inspirational. He made us all proud to be planetary explorers. Congratulations again, Alan, to you and the entire *New Horizons* team.

While *New Horizons* has been a complete success, European Space Agency's *Schiaparelli* lander did not fare as well. During its October 19 landing descent, *Schiaparelli* ran into trouble



Alan Stern accepts The Cosmos Award for the New Horizons team.

and crashed on Mars. On November 23, ESA issued an update on their investigation, identifying a faulty reading from the lander's Inertial Measurement Unit (gyroscope) as the cause of the crash. Landing had proceeded normally through parachute deployment and heat shield release, but the problem with the gyroscope made *Schiaparelli* think it had already landed. These software troubles remind us all, yet again, that planetary exploration is hard.

On the upside, *Schiaparelli's* parent spacecraft, the *ExoMars Orbiter*, is doing fine. We are getting new, three-dimensionally constructed pictures of regions on Mars that have never been seen in this much detail. If you're like me, you're hoping that soon we will find a suitable place to look for life on Mars, Europa, and perhaps other worlds. In the meantime, look up every day and consider the remarkable times in which we live, and the amazing discoveries that are just waiting to be made. 🚀

Bill Nye

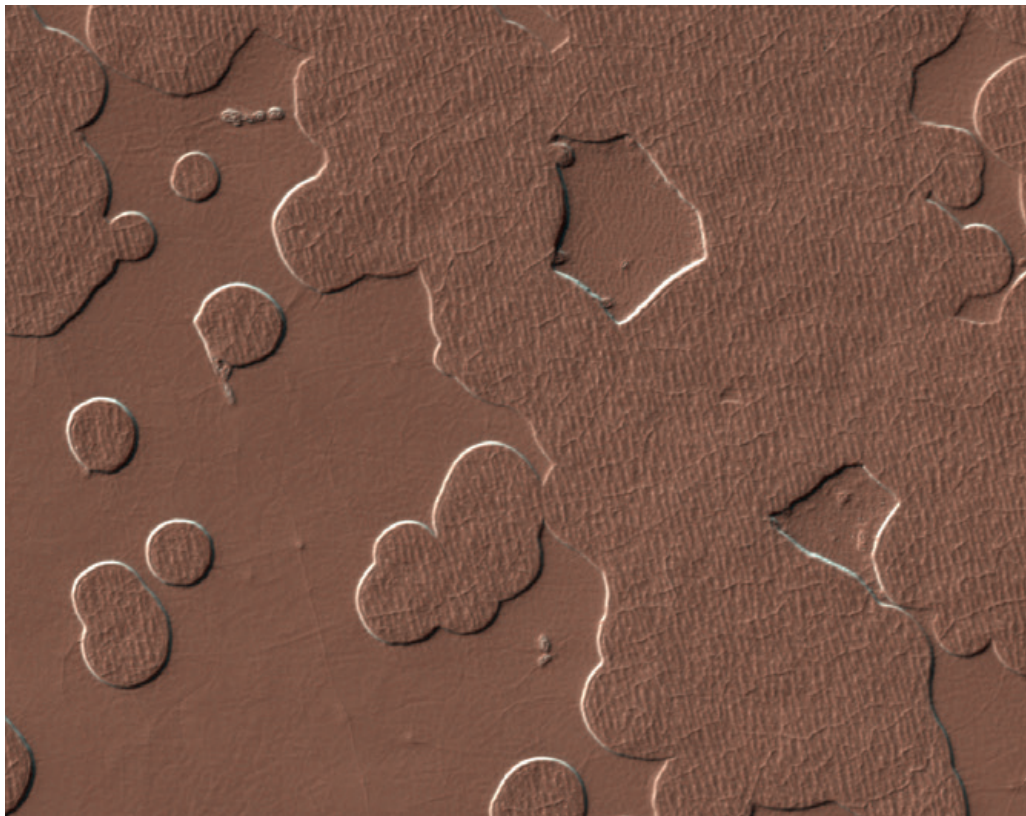


EMILY STEWART LAKDAWALLA

blogs at planetary.org/blog.

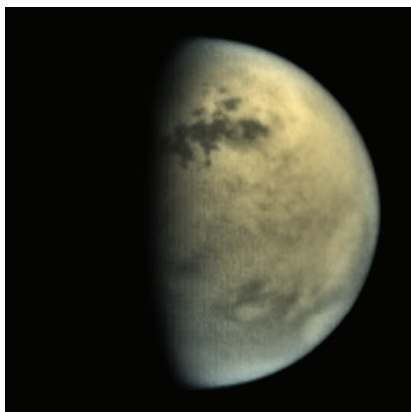
THE YEAR IN PICTURES

WITH MORE THAN twenty spacecraft in operation, 2016 was a peak year for solar system exploration activity. The start of *Akatsuki's* and *Juno's* science missions meant that, once again, data began flowing from Venus and Jupiter. *OSIRIS-REx* launched on its mission to an asteroid, and *ExoMars* blasted off and arrived at Mars, though the touchdown for its *Schiaparelli* lander went hard. *New Horizons* began its science mission in the Kuiper belt beyond Pluto, and all the aging Mars craft survived the year. The only mission to end was *Rosetta*. In 2017, we'll begin to see the interplanetary fleet contract, so enjoy this peak. 🚀



ABOVE Summer has reached Mars' south pole, where orbiters are watching the Sun's effects on the planet's seasonal and permanent polar caps. This view from MRO's HiRISE takes in the weird cusped scarp features of the permanent polar cap.

THE YEAR IN PICTURES



ABOVE Close to the end of its mission, Cassini has witnessed nearly half a Saturnian year of seasonal changes on the ringed planet and its moons. Throughout 2016, it photographed Titan's north polar lakes as they bathe in summer sun, and looked for changes in their shape and in the composition of the atmosphere due to the shifting seasons.

RIGHT On October 19, European Space Agency's ExoMars mission arrived at Mars. The orbiter went into orbit safely, but the lander, Schiaparelli, crashed. However, the Schiaparelli experiment was largely a success, employing a heat shield and parachute to slow its descent to the surface and then cutting ties to the parachute while transmitting extensive telemetry to waiting orbiters. Unfortunately, a software error appears to have doomed the landing in its final minutes, and the lander crashed at a speed of more than 80 meters per second. The dark ejecta around the crater (first image) are likely the hallmark of an explosion of its remaining fuel upon impact. By contrast, the light-colored backshell and parachute (second image) settled gently to the surface. A few days later, MRO captured these color images of the sad site.



ABOVE On June 28, a massive flame blasted a Utah hillside in the final qualification test of the new five-segment solid rocket booster that will be used for NASA's Space Launch System (SLS). The first flight of SLS is scheduled for 2018 and will send an uncrewed Orion spacecraft on a three-week trip to lunar orbit and back.



OPPOSITE PAGE Opportunity spent 2016 exploring Marathon Valley, a region on the rim of Mars' Endeavour crater. Marathon Valley has been a target for Opportunity since scientists analyzing Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) spectral maps found evidence for iron- and magnesium-rich clays there. Photos like this one from MRO's High Resolution Imaging Science Experiment (HiRISE) instrument have provided the Opportunity team with maps to guide their future travels. The valley marked "gully" is the goal for Opportunity's next extended mission. HiRISE continues to take new photos documenting the rover's progress.



SOL 3021

SOL 4453

"MARATHON VALLEY"

SOL 3952

"WHARTON RIDGE"

SOL 4485

"BITTERROOT VALLEY"

"SPIRIT MOUND"

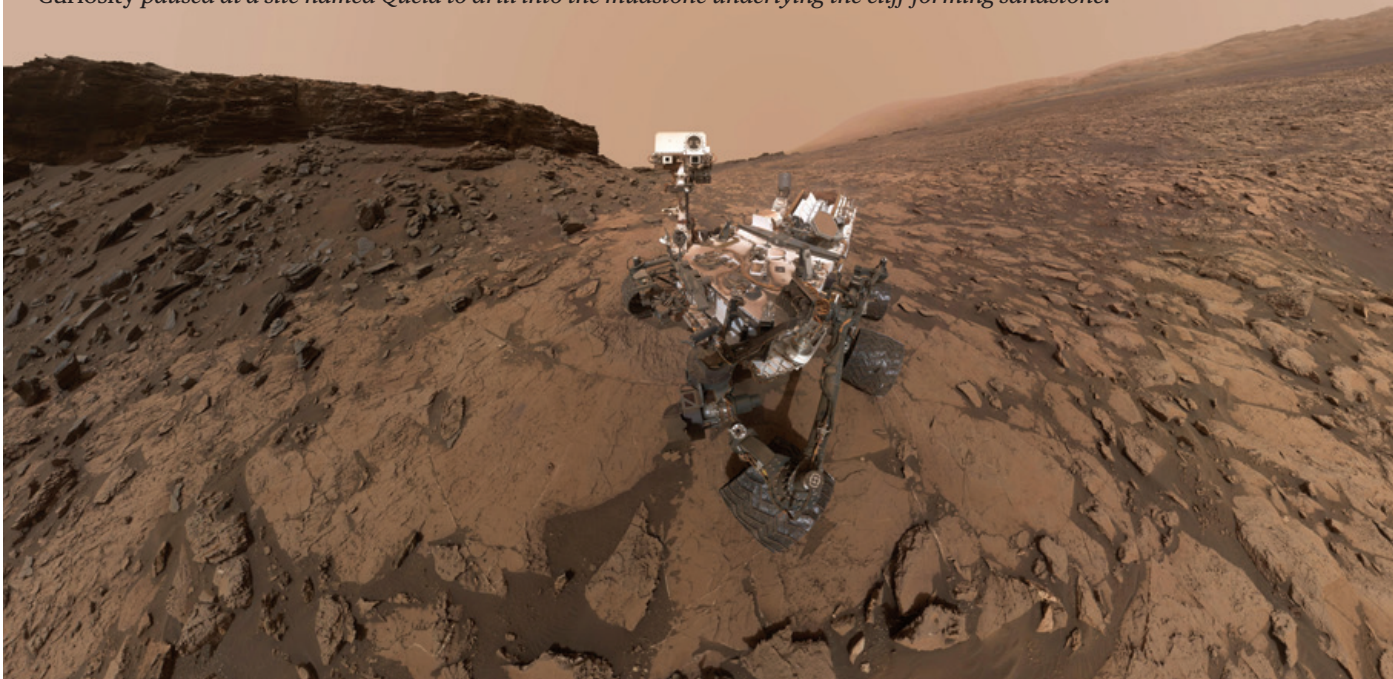
SOL 4077

"LEWIS AND CLARK GAP"

SOL 4500

GULLY

For four years, the Curiosity mission team has known they were driving toward a dramatic landscape of plateaus called the Murray Buttes, named for The Planetary Society's cofounder, Bruce Murray. The Murray Buttes are a place where a barrier dune field thinned out, and driving among them would allow Curiosity to access interesting rock layers on the other side of the dunes. In the summer of 2016, Curiosity drove rapidly through the Buttes, taking numerous photos of the sandstone-capped hills. Here, on sol 1463 (September 17, 2016), Curiosity paused at a site named Quela to drill into the mudstone underlying the cliff-forming sandstone.



RIGHT Beyond Marathon Valley, Opportunity entered Bitterroot Valley, climbing atop a low hill named Spirit Mound. On sol 4526 (October 17, 2016), it took a look south toward its future path along Endeavour crater's rim.

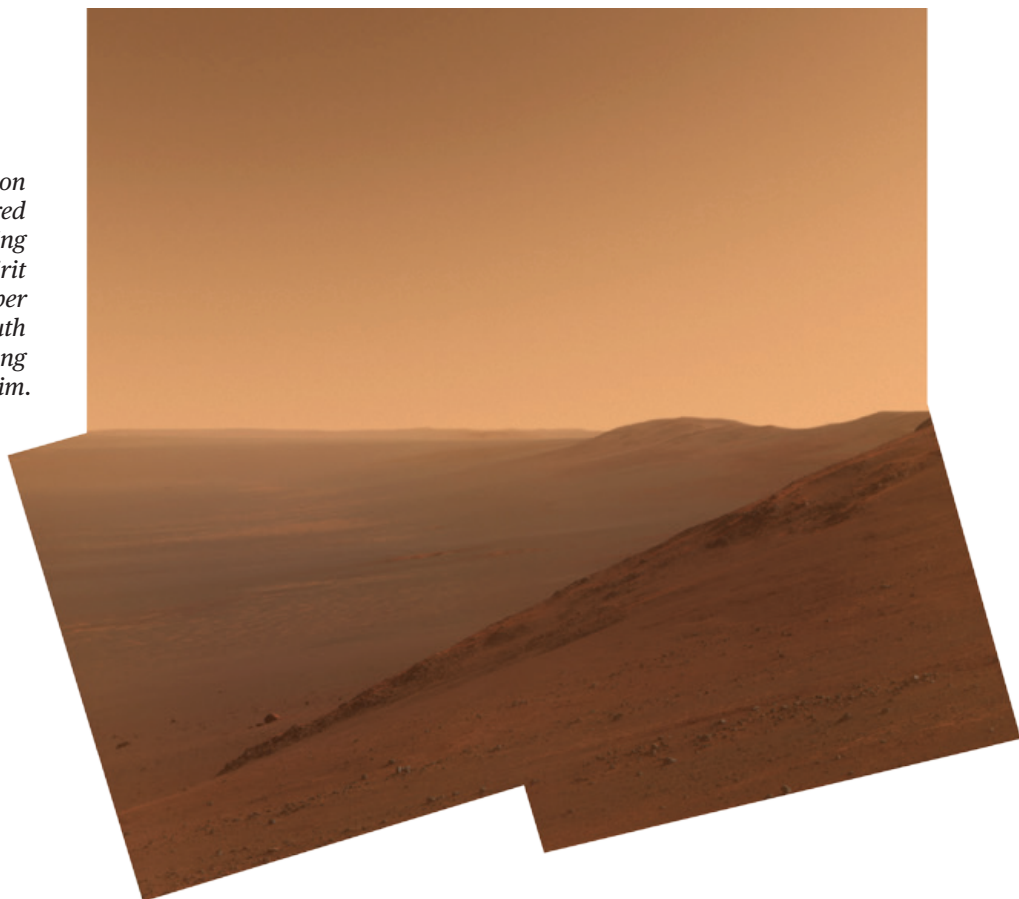
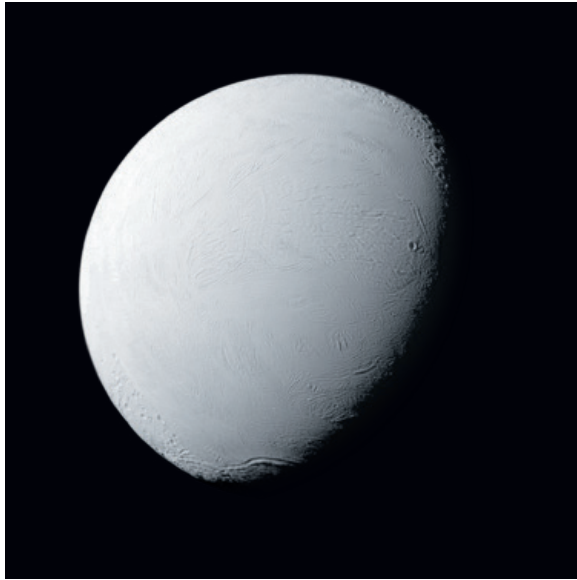
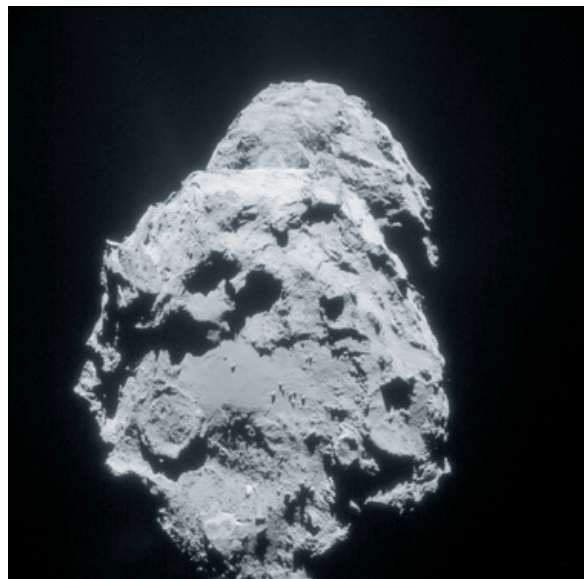
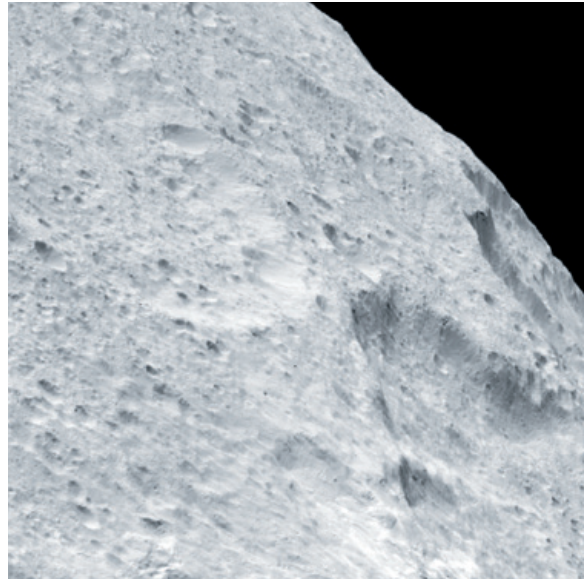


Image: top: NASA/JPL/MSSS; bottom: NASA/JPL/Cornell/SU/James Sorenson

BELOW Cassini took portraits of a few of Saturn's moons on January 19 before shifting to a more tilted orbit for the rest of 2016. These two similar-sized worlds, Mimas [bottom] and Enceladus [top], are a study in opposites, one heavily cratered, one smoothed by active geology.

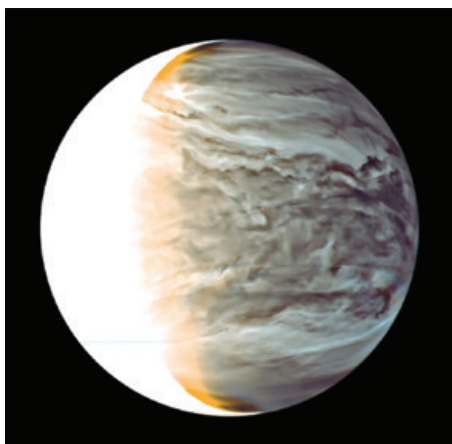


BELOW Dawn spent much of this year in a low orbit at Ceres, taking high-resolution photos and mapping the dwarf planet's surface composition. NASA has extended Dawn's mission, and the spacecraft will remain at Ceres for as long as its remaining fuel lasts. Oblique-angle photos such as this one, taken January 4, will help scientists improve their topographic maps.



ABOVE Rosetta's NavCam gave Earth thousands of views of the oddly shaped comet as it served to help navigators guide the spacecraft and provided context images for the science instruments. Through 2016, ESA worked to release all NavCam images to the public within weeks of their acquisition. This photo was taken on February 2.

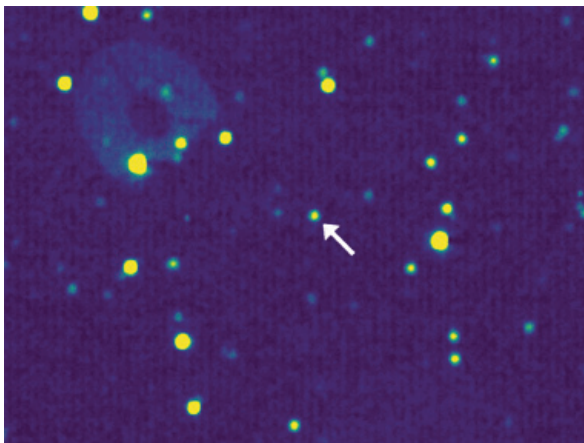
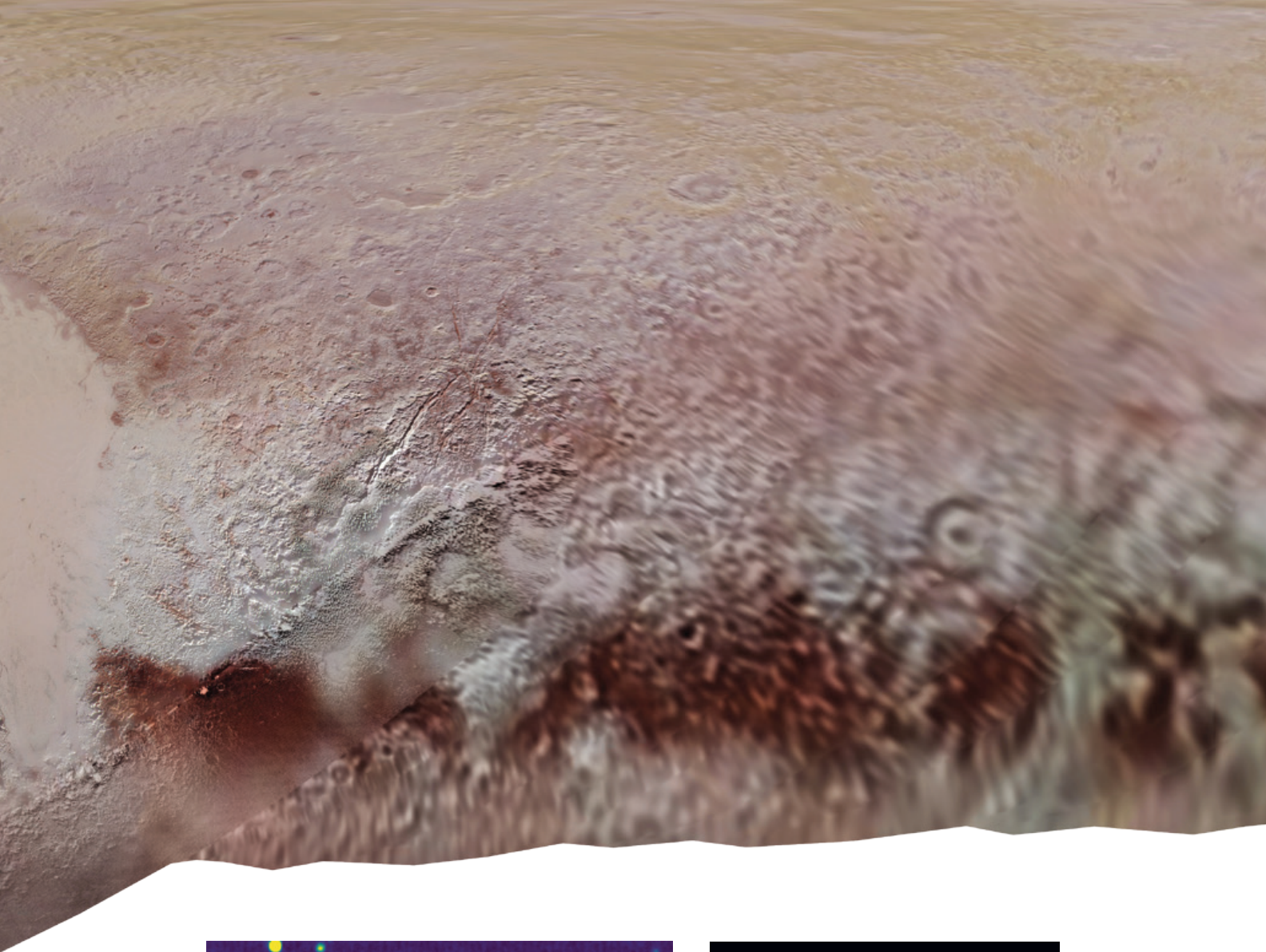
Images: Enceladus: NASA/JPL/SSI/Justin Cowart; Mimas: NASA/JPL/SSI/Björn Jönsson; Ceres: NASA/JPL/USCLA/MPS/DLR/IDA; Churyumov-Gerasimenko: ESA/Rosetta/NavCam



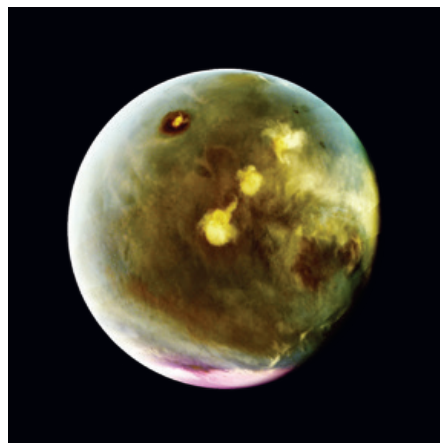
ABOVE After a six-year delay due to the failure of its main engine during its first attempt at orbit insertion, JAXA's Akatsuki orbiter finally began its science mission at Venus this year, studying the dynamics of all levels of its atmosphere through an array of cameras. This photo is made of images captured in near-infrared wavelengths, showing cloud patterns on Venus' night side.

ABOVE Late in 2016, New Horizons completed the return of the entire data set from its 2015 flyby of Pluto. The mission can now turn its hand to analyzing the data, producing processed versions of the data sets that will remain the best maps of Pluto for decades to come. This map shows color variations across the surface of Pluto; the colors are enhanced to exaggerate differences among them. Scientists note how Pluto's color shifts from orange in the polar latitudes, to pink in the middle latitudes, to dark near the equator, and bright at Pluto's "heart," Sputnik Planitia. The dark equatorial band is the part of Pluto that can receive sunlight year-round, while everything above and below it is alternately in summer sun or winter darkness.

Images: map: NASA/JHUAPL/SwRI; Venus: JAXA



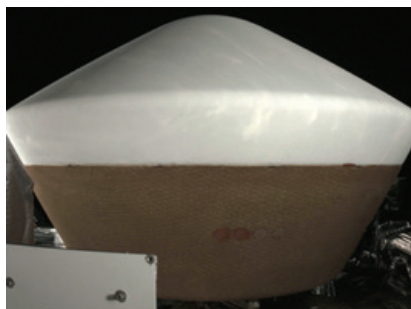
ABOVE New Horizons completed returning all its Pluto data this year as it cruised toward rendezvous with a second, smaller Kuiper belt target on January 1, 2019. In the meantime, the spacecraft is taking photos of other small Kuiper belt objects, such as this image of 1994 JR1. Though they don't show any detail, such observations help scientists determine rotation rates, detect satellites, and understand surface properties. New Horizons will eventually observe more than 20 such worlds.



ABOVE From its highly elliptical orbit, Mars Atmosphere and Volatile Evolution mission (MAVEN) has been watching Mars' atmosphere for more than a Martian year. This image is from a series of observations, taken with the spacecraft's Imaging Ultraviolet Spectrograph, which documented the growth of clouds above the peaks of Mars' tall volcanoes over the course of a Martian day on July 9-10. Clouds also fill Valles Marineris, on the right of the disk.

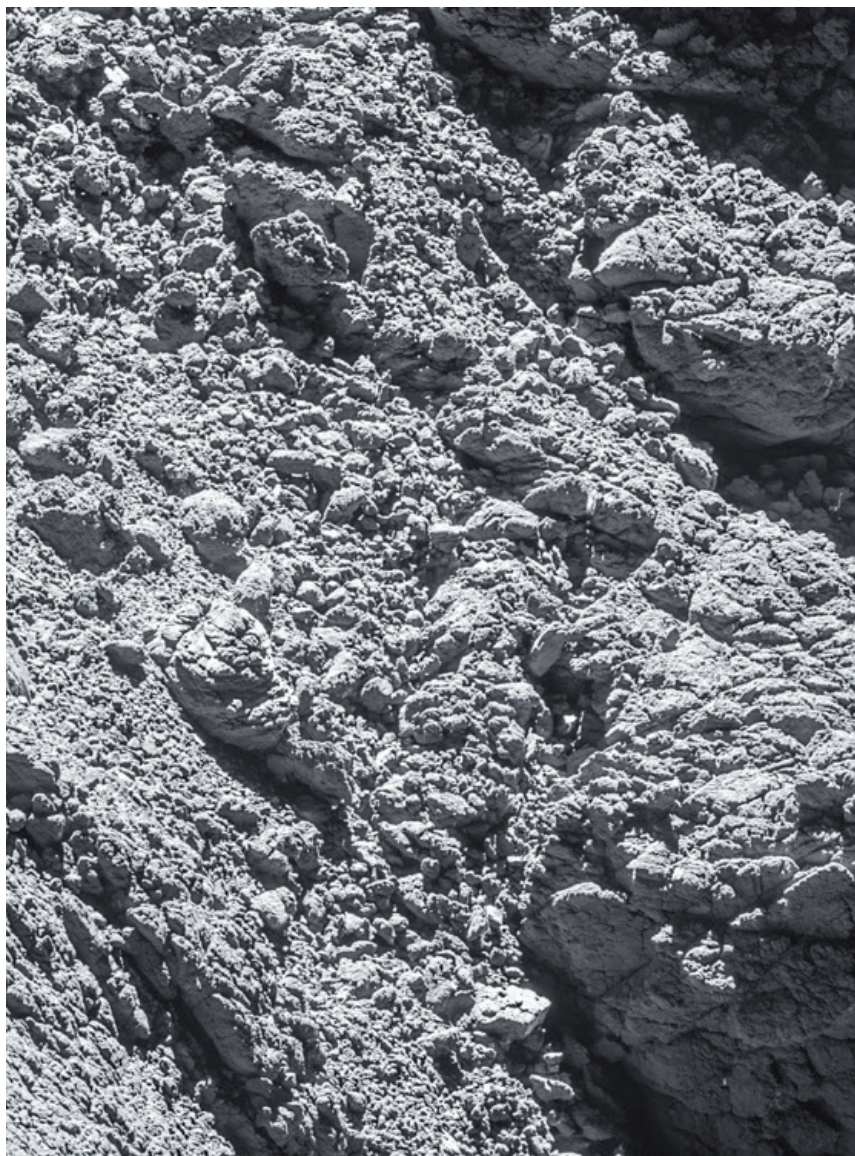
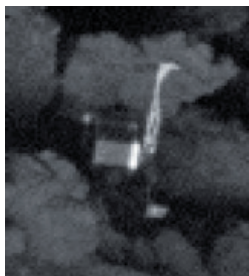
THE YEAR IN PICTURES

RIGHT Curiosity finally reached the massive dunes of the Bagnold dune field early this year, examining the windblown grains of an active sand dune on Mars for the first time. This image is only 17 millimeters (two thirds of an inch) wide, and shows the dune to be made of a huge variety of different types of minerals.



ABOVE OSIRIS-REx was NASA's only planetary launch of 2016, setting off for asteroid Bennu on September 8. This photo, taken two weeks later, shows OSIRIS-REx's return capsule sitting in space, waiting to receive asteroid samples for return to Earth in 2023.

RIGHT After almost two years of searching and just a month before the end of the mission, Rosetta finally spotted tiny Philae (enlarged below) resting in a crevice on the comet on September 2. The photo will help Philae scientists place their lander's precious data in context.



Images: sand: NASA/JPL/MSSS; OSIRIS-REx: NASA/MSSS/UA; comet: ESA/Rosetta/MPS for OSIRIS-REx Team MPS/JPL/AM/IAA/SSO/INTA/UPM/DASP/IDA



KATE HOWELLS is *The Planetary Society's Volunteer Network Manager.*

Come on an Adventure With Us!

Attention Planetary Society members: we welcome your participation in these upcoming trips! You will enjoy delightful adventures as you travel with noted astronomers and fellow Society members.

ALASKA AURORA BOREALIS - THE GREATEST LIGHT SHOW ON EARTH!
MARCH 2-8, 2017

Experience the startling beauty of Alaska in winter and marvel at the extraordinary Aurora Borealis in its night skies. Travel from Anchorage to the Kenai Peninsula with astronomer Tyler Nordgren. Take the train from Talkeetna past Denali (the tallest peak in North America) to Fairbanks, where you'll visit the Aurora rocket range, the Ice Festival, and more!

SUN VALLEY IDAHO TOTAL SOLAR ECLIPSE INCLUDING THE GRAND TETONS AND YELLOWSTONE
AUGUST 18-26, 2017

Watch the total solar eclipse from the top of Bald Mountain at Sun Valley on August 21, 2017. Plus, see the World Center for Birds of Prey, the Hagerman Fossil Beds, the Mammoth discovery of 2014, and more on a trip from Boise to Jackson Hole and Yellowstone!

GREAT WHALES IN BAJA CALIFORNIA - ENJOY A WILDERNESS PARADISE AND LUNAR ECLIPSE!

JANUARY 27-FEBRUARY 4, 2018
Take in the whale extravaganza and the Baja California desert wilderness on board the *M/V National Geographic Sea Bird*. Travel with Tyler Nordgren and see the lunar eclipse January 31, 2018 in this exciting desert wilderness of perfect 70-degree days and sparkling clear skies. Hike desert islands, snorkel with sea lions, and see California gray whales in the whale nursery of Magdalena Bay.

Join fellow Planetary Society members on these thrilling adventures! To learn more, call Betchart Expeditions at 800-252-4910, or visit betchartexpeditions.com.

Planetary Ambassadors

AT THE PLANETARY SOCIETY, we are always working to communicate with and grow the world's community of space enthusiasts, and to share our passion for space exploration. We speak, tweet, post, blog, film, write, even sometimes sing and dance (see our *Random Space Fact* videos on YouTube for an example of that last



one!). But there's only so much work we staffers can do ourselves.

That's why we value our Global Volunteer Network so highly. Our amazing team of volunteers from around the world is working hard to help share The Planetary Society's message about space science, exploration, education, and advocacy.

Our volunteers act as our ambassadors by getting out into their communities and connecting with local science festivals, university fairs, conferences, star parties, schools, and much more. With talks, demos, handouts, posters, and props, our amazing outreach coordinators reach out and spread the word that everyone on Earth can play a part in the adventure of space exploration.

To see if we have a representative near you, visit planetary.org/about/volunteers. And if you want to get involved yourself, go to planetary.org/volunteer. 🚀



ABOVE LEFT Planetary Society volunteers spread the word at Carnegie Mellon University in Qatar.

ABOVE Outreach coordinator Marvin Janssen works the "Night of the Night" star party in the Netherlands.



JASON DAVIS is a journalist and digital editor for *The Planetary Society*.



Rocket Road Trip

A Space Reporter's Notebook

ABOVE RIGHT NASA's OSIRIS-REx spacecraft blasts off from Cape Canaveral atop an Atlas V rocket on September 8, 2016. OSIRIS-REx will spend two years traveling to asteroid Benu, where it will collect a sample for return to Earth. The Planetary Society's Rocket Road Trip began at Kennedy Space Center, where we were able to witness the launch.

DO YOU ENJOY in-depth space reporting? The Planetary Society is one of just a few space exploration organizations that maintain a small staff of professional journalists. The Society's journalists make an effort to go beyond the press release and bring you a unique blend of space news analysis, breathtaking imagery, and deep-dive looks at important space topics.

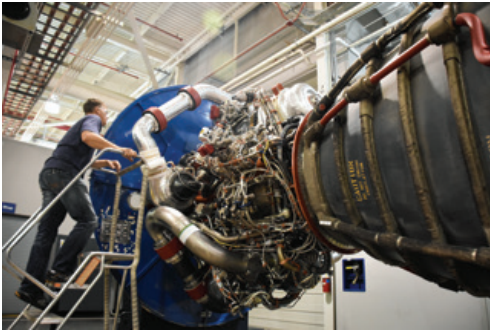
We support all three branches of The Planetary Society's core mission: to create, educate, and advocate. When the organization creates a project like *LightSail*, it's our job to bring you the story. We educate with our one-of-a-kind online, print, video, and radio stories. And we support the Society's efforts to advocate by untangling complex space policy topics with deeply researched stories.

This year, we embarked on a reporting project called Horizon Goal, which borrows its title from a National Research Council report endorsing Mars as the destination for NASA's

human spaceflight program. Horizon Goal traces the complex political and programmatic evolution of NASA's Journey to Mars program. It's a story we think is especially important as the United States goes through a presidential transition amidst the largest restructuring of NASA's human spaceflight program in four decades.

We knew from the beginning that this project would require us to get out and do something I'm passionate about: good, old-fashioned journalistic field work. Thus was born the Rocket Road Trip: a ten-day, four-state tour of NASA field centers and businesses throughout the southern United States that represent the heart of the agency's Space Launch System and Orion programs.

Joining me on the investigation was Casey Dreier, our director of space policy, and Merc Boyan, our creative director and videographer. Together, we captured hours of unique material that have been turned into a five-part



LEFT An Aerojet Rocketdyne technician works on an RS-25 engine that will power the Space Launch System.

RIGHT In late 2017, NASA will test-fire the first SLS core stage at Stennis Space Center in Mississippi.



ABOVE LEFT Jason Davis, Casey Dreier, and Merc Boyan pose in front of the first completed SLS hydrogen tank.

ABOVE A panoramic photograph of the flame trench at launch complex 39B, where a former space shuttle pad is being transformed to support SLS.



LOWER LEFT The “model room” at the Michoud Assembly Facility in New Orleans, where NASA has built rockets since the Apollo era.

LOWER RIGHT The Orion capsule that will fly on Exploration Mission 1 in 2018.

video series.

In the meantime, I wanted to share a few of our favorite photos from the trip and personally thank you for financially supporting our reporting efforts. I truly believe The Planetary Society can be a world leader in high-quality space journalism, and through projects like this, we're getting there.

To watch our five-part Rocket Road Trip video series, go to planet.ly/rockroadtrip2016.

Our entire Horizon Goal series is available at planetary.org/horizongol. We also have a Flickr album with more photos posted at planet.ly/rocketpics.

As we plan for the future of our space news reporting, I'd love to know what you think. Are you passionate about deep-dive stories like Horizon Goal? What space topics would you like to see us cover? E-mail your thoughts to jason.davis@planetary.org.



AMIR ALEXANDER is an author and science writer for *The Planetary Society*.



Making Space for Our Past

How The Planetary Society, With Help From a World-Class Library, Secured Its Legacy

ABOVE Pasadena, California, home of the Jet Propulsion Laboratory, the California Institute of Technology, and The Planetary Society, is a “space town.” It is also home to the Huntington Library, one of the world’s great cultural, research, and educational institutions. One of the Huntington’s many research specialties is the history of science. Under this umbrella, their growing archives on the history of aerospace in Southern California now include documents and memorabilia from The Planetary Society’s history.

NO ONE WHO VISITED The Planetary Society’s headquarters in Pasadena over the years could have failed to be impressed by the organization’s rich history. It seemed to stare back at them from every wall: here hung the large, plaster model of Mars’ Valles Marineris, used in Carl Sagan’s *Cosmos* television series; there one could enjoy colorful posters from past planetary encounters and Planetfest™ festivals. In the attic, in the basement, and even in the bathroom, one might see boxes upon boxes of old documents, letters, posters, and tapes. The Society’s history was everywhere, a treasure trove accumulated decade by decade since the Society’s founding. But there it sat, unsorted in a jumble.

There is, perhaps, a simple excuse for this seeming disorganization: we at The Planetary Society are focused on the future. The future, in fact, is so ingrained in our outlook that it took us a long time to realize something very simple: The Planetary Society also has

an important past.

Our story began in 1979 as Carl Sagan, Bruce Murray, and Louis Friedman began a grassroots organization dedicated to re-igniting a planetary exploration program that seemed on the verge of fading away. Their new organization soon experienced explosive membership growth, which fueled intense, effective political advocacy and facilitated international partnerships. These partnerships resulted in the development of groundbreaking projects such as the first solar sail (the only known technology that could someday take us to the stars) and an early prototype Mars rover. Right from the start, we supported projects such as the Search for Extraterrestrial Intelligence and the study of potentially hazardous near-Earth objects. The list of our visionary work goes on and on.

Through it all, The Planetary Society has been a partner and, ultimately, a leader in the citizen-led space community. So much so that

it is fair to say that one cannot understand the story of space exploration in the late twentieth and early twenty-first centuries without recognizing the key part played by the Society. And so, as we approached the 35th anniversary of the founding of the Society, we acknowledged that our future-oriented organization has a remarkable history and legacy, and it must not be lost.

SAVING OUR PAST FOR THE FUTURE

The process began slowly. Around 2010, then-Society Executive Director Louis Friedman needed a list of all the Society's board members since its founding. It was a straightforward request, and it landed on the desk of Tom Kemp, our global volunteer coordinator. Tom, as he tells it, set to work but soon found that, given the state of the Society's historical records, coming up with the list was far from simple. The experience left Tom painfully aware that if even a simple list of board members required weeks of research and tabulating, it would be a challenge to

professional historian Siobhan Gephart, and in 2012 they put together a proposal for writing an official history of The Planetary Society. They realized that before such a project could get underway, the mass of materials accumulating in the Society's storage facilities needed to be reviewed, sorted, catalogued, and transformed into an organized and searchable archive.

Some time later, I was approached by Jennifer Vaughn, the Society's chief operating officer. Who, she asked me, would be up to the challenge? After thinking it over and consulting with colleagues, I came up with what seemed to me an ideal answer: The Huntington Library.

A WORLD-CLASS SCIENCE AND TECHNOLOGY LIBRARY

Unbeknownst to me, the idea of donating the records and materials of The Planetary Society's past to the Huntington had already been floated in casual conversation. And no wonder: it seemed like a perfect match. The Huntington is one of the leading centers of research on

LEFT On December 3, 1999, Sir Arthur C. Clarke wrote to Society cofounder Bruce Murray to confirm his continuance as a Planetary Society Advisory Board member. Unfortunately, his good wishes for the fate of the Mars Polar Lander's touchdown on the Red Planet did not come true.

RIGHT When Voyager 1 encountered Saturn in 1981, the newly formed Planetary Society held a multi-day festival called Planetfest™ to celebrate the momentous occasion. Shown here is the event's program cover. Our Planetfests have become a beloved tradition for celebrating large milestones in space exploration.

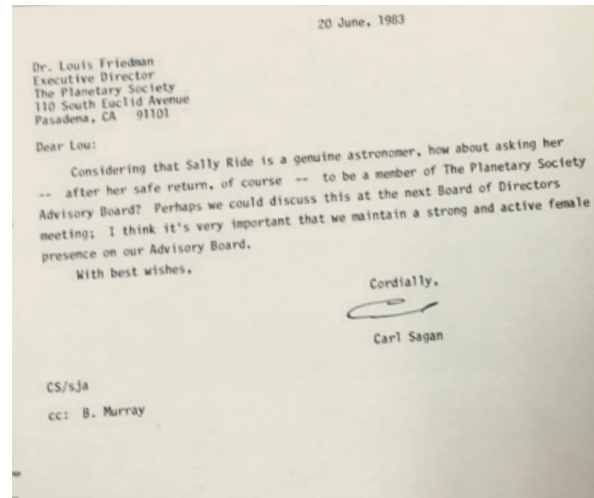


document other people and events from the Society's past. If something was not done, and soon, memories and records could be lost forever.

He consulted with fellow volunteer and

the history of science and technology and is home to one of the largest collections of books and documents in the field. Turning heaps of papers and materials into a functioning historical archive is what the people of the

AMIR ALEXANDER teaches the history of science at UCLA. His latest book, *Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World*, was selected as one of Slate's best books for 2014.



ABOVE LEFT AND CENTER
From cardboard boxes in a rented storage locker to searchable archives in a climate-controlled facility, The Planetary Society's history has landed in the right place. Brook Engbretson holds one of the boxes that protect our large collection of 35-millimeter slides. To her left is assistant Laurelin Kruse.

ABOVE RIGHT *Carl Sagan wrote this letter to Louis Friedman and Bruce Murray on June 20, 1983. Astronaut Sally Ride soon became an active member of our board of advisors and remained on it for many years.*

Huntington do every day, and they are as good at it as anyone on the planet. The Huntington was also, I knew, actively collecting materials on the history of aerospace, in which the Society played such a crucial role. And last but not least, like the Society itself, the Huntington Library is a Pasadena institution, part of the same cultural fabric that makes this leafy Southern California town unique. Who would be a better guardian of the Society's history and legacy than this world-class library, specialists in the history of science, located just down the road from our own headquarters?

I contacted Bill Deverell, director of the Huntington-USC Institute on California and the West, and Peter Westwick, a leading expert and author on the history of aerospace in Southern California. They put me in touch with Dan Lewis, the Huntington's curator for the History of Science and the man who would be in charge of all aspects of the collection at the Library.

Dan did not need much convincing. "It was a perfect fit," he recalled recently, explaining why he wanted to bring The Planetary Society Collection under the Huntington's roof. At the Huntington, he said, "We want to document everything about aerospace, from the shop floor to the boardroom." The Library already had collections from private corporations such as Northrop Grumman and Lockheed Martin,

as well as from veterans of NASA and JPL. But the Society's materials offered something different: unlike private companies and governmental institutions, Dan explained, "the Society is a citizens' organization with an idealistic mission." As a membership organization that has been inspiring the broad public with the wonder of space exploration for the past 35 years, it added an entirely new dimension to the history of aerospace.

Dan knew the right person to take on the challenge of sorting through the Society's materials: Brook Engbretson, an archivist at the Huntington with a background in engineering and masters' degrees in both history and library science. There could be no better preparation for cataloguing a collection made up of both technical blueprints and historical correspondence. An agreement was soon reached between the Huntington and the Society, and Brook swung into action.

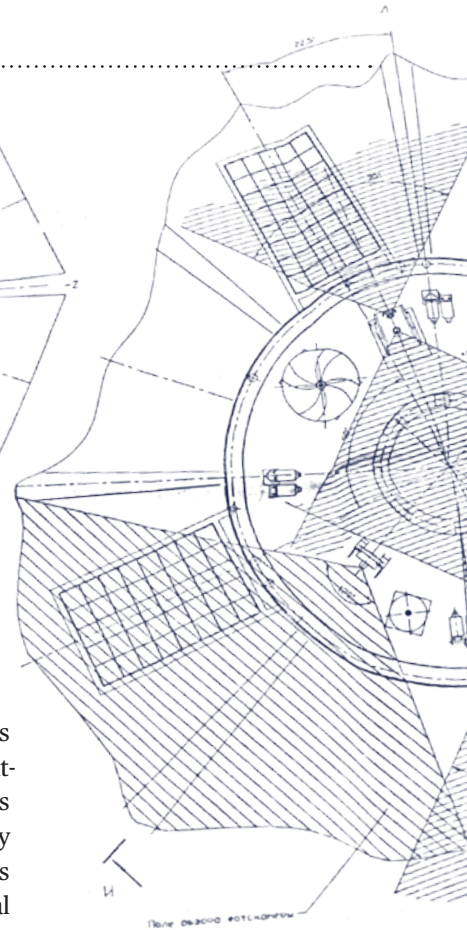
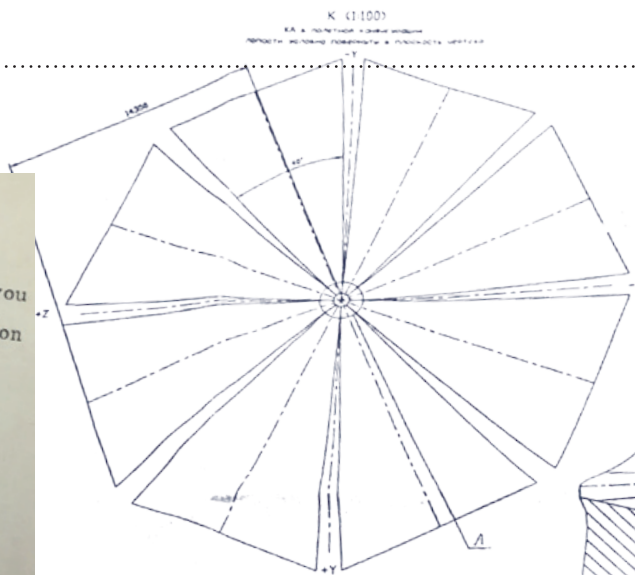
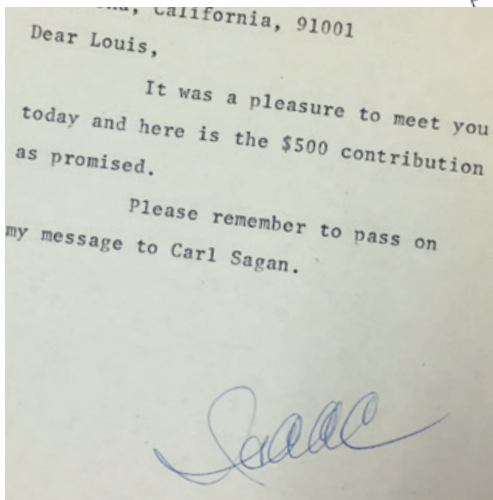
FROM A JUMBLE TO AN ARCHIVE

Brook still remembers the first time she came face to face with the Society's hodgepodge collection, by then housed in a storage facility in Pasadena. There, divided between two garage-sized lockers, were boxes of letters, documents, and memorabilia, spilling over and piled one on top of the other from floor to ceiling. Over the next year, she gradually

Thanks!

The Planetary Society's charter members donated the funds that made these archives possible. This project inspired Naïla Erwin to challenge other charter members to join her in pursuing fundraising and support for the Society (see page 2).

Storage and Huntington photos courtesy of the author



transferred the materials, box by box, to The Planetary Society's new headquarters on Los Robles Avenue in Pasadena. She set up shop in the project room and began to pore over the items. Later, the Huntington would hire Laurelin Kruse, who has a background in American Studies, to assist her.

The gems were not slow in coming. Here was a 1980 letter from science fiction author Isaac Asimov to Louis Friedman, contributing \$500 to the newly formed Planetary Society; there, original pictures from the trials of the Marsokhod rover on the Kamchatka peninsula and the Mars Balloon in Death Valley; a folded, innocuous-looking sheet of paper that turned out to contain the blueprint of the *Cosmos 1* solar sail. And, of course, there was Carl Sagan's CV, three hundred fifty pages long.

One by one, Brook and Laurelin went over all of them, arranged them in groups according to subject and theme, and described each one. Step by step they worked on creating what archivists call a "finding aid"—a book-length document that describes the collection in detail and helps researchers find and access what they need. When all was done, the now carefully organized items were packed into white bankers' boxes, loaded on a truck, and shipped to the Huntington Library, a mere ten-minute drive away.

Even as the collection arrived at the Huntington, Brook and Laurelin's work was not

done. They gradually transferred the items into special archival boxes, carefully tabulating and cataloguing their contents. As of this writing, this work is still ongoing as, box by box, The Planetary Society collection takes its place on the shelves of one of the great archival libraries of the world. When the process is complete, sometime within the next few months, researchers from around the world will be able to visit the Huntington and sort through the records of the Society's rich past.

NO BETTER OR SAFER PLACE

The collection now resides in the Huntington's new archival facility, located underground beneath the famous library and gardens. It is a fully climate-controlled environment, in which both temperature and humidity are carefully calibrated to protect and preserve the aging documents. In October 2015, The Planetary Society and the Huntington co-hosted a reception on the Library's beautiful grounds as part of our anniversary celebrations. The purpose of this reception was two-fold: to raise funds for the archives project, and to introduce it to our charter members. The evening was an all-around success and the project will be funded for years to come.

We at The Planetary Society will continue looking to the future, just as we always have, and sharing our vision with the world. But we will do so knowing that our past, too, is now in good hands. 🐼

ABOVE LEFT The newly formed Planetary Society was supported by donations from luminaries such as Isaac Asimov (shown), Paul Newman, James Michener, Arthur C. Clarke, Ray Bradbury and Johnny Carson. Asimov, Clarke, and Bradbury would remain on our advisory council until their deaths.

ABOVE RIGHT This is a detail from a portion of the *Cosmos 1* blueprint. Although a launch vehicle failure would doom *Cosmos 1*, this mission was a forerunner to *LightSail* and an essential chapter in the story of solar sailing.



BRUCE BETTS is director of science and technology for The Planetary Society.

The Home Stretch

Our Final Tests on *LightSail 2*

THE LIGHTSAIL 1 mission we flew in May and June 2015 successfully demonstrated solar sail deployment while also allowing us to test

Prox-1 spacecraft that will demonstrate automated trajectory control relative to a CubeSat in low-Earth orbit. *LightSail 2* will launch to orbit tucked inside *Prox-1*.

This launch is currently scheduled for no earlier than the third quarter of 2017. *Prox-1* and *LightSail 2* will blast off alongside many payloads on board the second flight of the SpaceX Falcon Heavy. The dates for the first two launches of the Falcon Heavy have slipped, in part due to a Falcon 9 explosion on the launch pad in September. We have utilized these slips in the Falcon Heavy's launch schedule to do more thorough testing and upgrades of *LightSail 2*.



ABOVE On December 6, *Ecliptic Enterprise's* Stephanie Wong and Alex Diaz prepared *LightSail 2* for its Day in the Life testing at Cal Poly, San Luis Obispo.

the spacecraft in orbit. *LightSail 2* will fly to a higher altitude with the goal of demonstrating controlled solar sailing from a CubeSat miniature spacecraft.

FINAL TESTING, DELIVERY, AND LAUNCH

We are currently in the process of final testing of *LightSail 2*. The testing will culminate in a simulation of key flight events and deployment of the booms. Following that final run-through and any necessary changes we identify, *LightSail 2* will be delivered to New Mexico's Air Force Research Laboratory (AFRL) in the first quarter of 2017. At AFRL, it will be integrated with the Georgia Tech-built

TESTING AND FIXES

Over the last several months we have made changes to both hardware and software to improve the reliability and operability of the spacecraft. One broad area of focus has been the attitude determination and control system (ADCS). This system controls the spacecraft's orientation and is critical to our goal of controlled solar sailing with *LightSail 2*. We have also used facilities at both Utah State and UCLA to do things such as calibrating the sensors, including the magnetometers. And we have also tested the torque rods that will make minor adjustments to the orientation of the spacecraft, as well as the momentum wheel that will be responsible, twice per orbit, for rotating the spacecraft and changing the orientation of the sail relative to the Sun.

Various hardware fixes and upgrades have also been made to *LightSail's* power system, primarily involving the batteries and circuits that protect the batteries. The spacecraft also passed the critical vibration tests that

Thanks!

Planetary Society members have helped make *LightSail*—and many other projects—possible! Thank you.

simulate shaking during launch, as well as thermal vacuum tests that simulate the space environment.

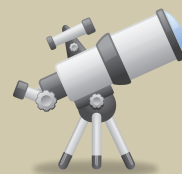
Software is a critical component of the spacecraft; it runs everything from the computing system to the ADCS system to communications with Earth. Once we upgraded the software, we tested it extensively. We have implemented software timers that will reboot portions of the spacecraft or the entire spacecraft if something is not working right for a given period of time, which is usually measured in minutes. With *LightSail 1*, we had software and communications issues that would have been fixed by a reboot. With *LightSail 2*, our software will look for those situations and reboot automatically. There is even a long-term timer built into the hardware that will reboot the spacecraft every 12 days. Similar to restarting your computer, the reboots will place the spacecraft into a known, clean state and serve as a safety net in the event a major system fault occurs and prevents the short-duration component-level resets from clearing the problem. We are not just trying to make things work right; we are also designing contingencies in case things go wrong.

PUBLICATIONS AND PRESENTATIONS

We recently published a detailed paper about *LightSail 1* (including lessons learned) in the peer-reviewed *Journal of Small Satellites*. We have submitted papers and will be doing presentations about *LightSail 1* (both the mission and its successful public involvement and outreach) and about *LightSail 2* at the International Solar Sailing Symposium in Kyoto, Japan in January. Last but not least, we've been completing the necessary applications for regulatory approval for operating a spacecraft.

LEARN MORE

To keep up with current, past, and future *LightSail* mission news, visit our solar sailing mini-website at sail.planetary.org/missioncontrol, check out our *Planetary TV* and read Jason Davis' blogs at planetary.org. 🚀



IN THE SKY

Bright Venus dominates the West after sunset. Much dimmer, reddish Mars is visible to its upper left. They grow closer through January and farther apart in February. Bright Jupiter is rising in the East around midnight at the beginning of the year, but is up in the early evening East by March. An annular solar eclipse crosses parts of South America and southern Africa on February 26, 2017. This eclipse will be partially visible throughout much of South America and Africa.



RANDOM SPACE FACT

If a 1960s *Mercury*-type capsule—the type that first took Americans to space—were the size of a hummingbird with a wingspan of about 11 centimeters, or 4.3 inches, then on the same scale, the International Space Station would have a “wingspan” (3.65 meters, or 12 feet) equivalent to that of the largest living bird: the Wandering Albatross.



TRIVIA CONTEST

Our June Solstice contest winner is David Lee Summers of Mesilla Park, New Mexico. Congratulations! **THE QUESTION WAS:** Within the Local Group of galaxies, what is the name of the one other galaxy that is similar in size to, or larger than, our own Milky Way Galaxy? **THE ANSWER:** The Andromeda Galaxy, also known as M31.

Try to win an autographed copy of *The Space Book* by Society president Jim Bell, and a *Planetary Radio* T-shirt by answering this question:

What are the names of Pluto's known moons?

E-mail your answer to planetaryreport@planetary.org or mail your answer to *The Planetary Report*, 60 S. Los Robles Ave., Pasadena, CA 91101. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one). By entering this contest, you are authorizing *The Planetary Report* to publish your name and hometown. Submissions must be received by March 1, 2017. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of “What’s Up?” complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to *Planetary Radio* at planetary.org/radio.



JASON CALLAHAN is space policy advisor for The Planetary Society. **CASEY DREIER** is director of space policy for The Planetary Society.

Laying the Groundwork

The Planetary Society's Recommendations to the New U.S. Administration



ABOVE *Space exploration inspires awe, transcends partisan politics, and unites us all under the umbrella of something larger than ourselves. Over the next four years, steps taken by NASA can leave a positive impact, both domestically and internationally.*

IN THE PAST decade, NASA has been a consistent source of major success stories that have captured the public's imagination, including landing on Mars, flying by Pluto, enabling a vibrant new commercial launch industry, and beginning a journey to Mars. These feats have incalculable impact on the United States' mood and sense of optimism for the future. Among the many factors that contributed to these achievements is the bipartisan political support that has continued over years, sometimes decades.

As you read this, a new U.S. presidential administration is transitioning into place. The new president will have an unusual opportunity in his first term to guide NASA through several critical milestones in human

and robotic spaceflight, and will also impart a lasting legacy by guiding NASA's historic effort to send humans to Mars.

Assuming the new administration does not attempt to drastically alter NASA's current plans (and we recommend that they do not), the next four years will see the United States once again launching astronauts into space from its own soil—not on NASA spacecraft, but on those provided by commercial partners. In this period NASA will test a new heavy-lift rocket and crew capsule, the Space Launch System (SLS) and Orion, respectively, enabling humans to travel beyond the vicinity of Earth for the first time since the early 1970s. Several major space science missions also will begin investigations of

the Sun (Solar Probe Plus), Mars (InSight), and the deep cosmos (the James Webb Space Telescope). Two robotic missions are in development and will launch in the early 2020s to advance the search for life at Mars (Mars 2020) and at the ocean moon of Europa (Europa Clipper).

NASA'S WIDER ROLE

In addition to supporting these near-term milestones, the next administration can use NASA as a tool to impart a positive, lasting legacy. Embracing the American civil space program presents a series of opportunities, including:

1 INVIGORATING THE AMERICAN WORKFORCE

A clear vision to send astronauts to Mars and engage

Image: NASA

in other challenging space endeavors can motivate young people to pursue careers in critical STEM areas. As work progresses in the grand goal of exploration, many people will inevitably direct their skills, entrepreneurship, and abilities into various industries beyond the aerospace sector. Meanwhile, NASA and its industry partners will continue to provide tens of thousands of jobs to the scientists, engineers, and others who do the work required to successfully explore the universe.

2 INTERNATIONAL RELATIONS THROUGH SPACE EXPLORATION

Space has served as a tool of international diplomacy since the early days of the space age. Nearly every NASA science mission includes scientists and instrumentation provided by other countries and encourages the sharing of scientific data and knowledge; the International Space Station is perhaps the grandest example of the diplomatic potential of space-based cooperation among nations. NASA is uniquely positioned to engage our allies and potential competitors in collaborative exploration of the solar system and beyond.

3 BIPARTISAN COOPERATION TO EXPAND THE SCIENCE CAPABILITIES OF THE UNITED STATES

Finally, the space program can provide a critical bridge between America's divided political parties. NASA has historically enjoyed broad bipartisan support from presidents and members of Congress. Citizens of all political orientations support NASA and space exploration. Engaging the U.S. Congress on bipartisan NASA issues can serve to build stronger connections and trust between the next president's administration and members from both major U.S. political parties.

To help the president plan a course for the United States' civil space program, The Planetary Society's board of directors—representing you as a member of the world's largest independent space organization—recently presented the incoming administration with a document outlining our recommendations for actions by NASA in the next four years that will help address major national needs and lay the groundwork for a historic legacy of exploration and commerce. These recommendations include:

- retaining Mars as the organizing principle of NASA's human exploration program;
- directing NASA to plan an executable, affordable path to send humans to Mars orbit by 2033 while strengthening the emerging Mars coalition of industry, science, and Congress;
- expanding NASA's highly successful science portfolio to enable the search for life and pursuit of answers to critical scientific questions, as recommended by the National Academies;
- initiating the "5 over 5" plan for NASA—annual five percent budget growth over five years; and
- fostering the commercial space industry to enable its rapid growth in capability.

This document is just one of the ways in which we are constantly engaging policy makers. All of our efforts are backed by our members (you!) as you express your support for space to your political representatives. Thank you. 🇺🇸



To stay up-to-date, see some of our recent blog posts:

NASA Under Trump
planet.ly/trumpandnasa

Space Policy Edition: *The Trump Administration: What Can We Expect for Space?*
planet.ly/trumpspacepolicy

And don't miss our monthly Space Policy Edition podcast on Planetary Radio. Subscribe to Planetary Radio on iTunes or listen free at planet.ly/planetaryradio

ON THE WEB



THE YEAR IN PICTURES

Jupiter's south pole from *Juno*

Juno entered Jupiter orbit on July 4, beginning a mission to orbit the planet over its poles to learn about its interior structure. *Juno* carries a small camera, JunoCam, for shooting photos from its unusual polar perspective. This photo takes in a surprising variety of cyclones and anticyclones at the south pole.

