Planetary Science Institute

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This overlook at Kīlauea Volcano was open to tourists until 2008 when the current eruptive activity at Kīlauea's summit began. The intense heat, as well as sulfur dioxide gases released from the lava lake below, can be felt at the overlook about 300 ft above.

David A. Crown at the active lava lake in the crater at Kīlauea's summit. The lake's surface crust is continually disrupted by circulating lava, release of gases, and the collapse of its near-vertical walls.

3D Mapping of Erupting Volcano in Hawai'i

Kīlauea Volcano, on the island of Hawai'i, is among the Earth's most active volcanoes, with more than 30 eruptions in the last 60 years. The current ongoing eruption of Kīlauea that began in 1983 continues to provide scientists an extraordinary first-hand opportunity to study volcanic processes relevant to understanding how volcanoes work on Earth and other planets.

PSI Senior Scientist and Assistant Director David A. Crown conducts field and remote sensing investigations of lava flows to characterize physical processes of volcanic eruptions. These characterizations have great value as Earth-based analogues to lava flows on Mars. In January 2013, he visited the hotbed of volcanic activity on Kīlauea to participate in field research with colleagues from the U.S. Army Corps of Engineers, the University of Northern Colorado, and the Hawaiian Volcano Observatory.

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Laser scanner system set up at the rim of Halema'uma'u Crater for topographic survey of the active summit vent.

Inside this issue:

Arizona, California, District of Columbia, Indiana, Maryland, Maine, New Mexico, Nevada, Oklahoma, South Carolina, Texas, Utah, Virginia, Vermont, Washington, Wisconsin, West Virginia, Wyoming

A Scientist at the State Department

PSI Affiliate Senior Scientist James Head, Ph.D., completed a two-year Science and Technology Policy Fellowship in August 2012. Sponsored by the American Association for the Advancement of Science (AAAS), Jim served in the Office of Space and Advanced Technology (SAT) at the U.S. State Department.

Jim Head steals a few moments in the boss's chair at the Vienna United Nations Committee meeting. He wishes our dear friend and colleague PSI Senior Scientist Betty Pierazzo (d. 2011) could have seen this.

Each year AAAS sponsors about 250 Fellows, 35 serving in Congress and the balance spread across 15 Executive Branch agencies. Most Fellows hold a Ph.D. in a scientific discipline; there were also Masters-level engineers, medical doctors, and one veterinarian. Jim's Ph.D is in planetary science from the University of Arizona's Lunar and Planetary Laboratory (LPL).

The Fellows provide science expertise for the policy process, both in formulation and implementation, and in return receive an unparalleled education in the operations of the federal government. Jim's Fellowship began with two weeks of orientation in September 2010, where experts in the public and academic sectors instructed the entering class of 140 on the philosophical underpinnings of the American experiment in government, the federal budget and process, executive and legislative processes and cultures, diplomacy and foreign policy, and science policy. This training was augmented throughout the Fellowship tenure with monthly professional development activities on a wide range of topics including: how to negotiate a Washington cocktail party*****, career planning, negotiation, public engagement, and sector-specific panels on jobs for Ph.D.s outside the laboratory. With about 1500 former Fellows working in government and non-governmental organizations in the D.C. area, the alumni constitute a formidable network of science and policy expertise.

SAT manages international aspects of America's civil space program and helps craft and implement each administration's National Space Policy. Jim's specific portfolio included space weather, space debris, and near-Earth objects, utilizing the expertise gained at LPL, a decade in the aerospace industry, and his interactions with PSI. PSI Director Mark Sykes wrote one of Jim's letters of recommendation for the Fellowship and they now discuss prospects for enhancing PSI's already significant international collaborations.

In his Fellowship role, Jim has participated in the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS, in Vienna), the International Astronautical Congress (Cape Town), the annual U.S.-EU space security dialogue (Madrid), and the European Space Weather Week (Belgium). He represented the international viewpoint to U.S. government agencies at venues such as Space Weather Week (Boulder) and NASA-sponsored workshops (NASA-Ames).

His first significant task was to lead the U.S. interagency process to craft the U.S. position on long-term sustainability of space activities[1], then to negotiate a consensus document and work plan at the UN that met U.S. objectives. He served on three expert groups established in that effort. In addition, Jim instigated and led an international effort to develop and adopt goals for cooperation in space weather research and operations. Jim worked closely with scientists and international specialists at NASA, NOAA, the National Weather Service, the Pentagon, USGS, and the FAA. Jim also drafted the remarks, spoken by the U.S. Ambassador to the UN Mission, commemorating the 50th anniversary of human space flight, in Vienna.

In Vienna, Jim Head concludes a seminar at the 55th meeting of a United Nations Committee on the Peaceful Uses of Outer Space. David Kendall of the Canadian Space Agency in on the left and on the right is a representative for the U.N. Office for Outer Space Affairs.

Jim rounded out his Fellowship experience by convening an international workshop on Space Weather Societal Impacts, held on the coattails of the 55th Meeting of the UN-COPUOS. The workshop was followed by a special seminar held before the Committee of 71 Member States and 20 Permanent Observers with simultaneous translation into the six official UN languages.[2]

Most Fellows pursue the many opportunities in government, academia, and industry that were not obviously available to them from their life "in the lab." Many Fellows, like Jim, return home, finding new ways to serve their communities.

****Cocktail party note:***
Use a napkin to hold your wine glass (wine or apple juice) in your left hand (keeps your right hand warm, dry, and ready for handshaking), do not eat (so you're always able to say hello), and approach people for conversation only if they are alone or there are more than two in the group, among other tips.

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Chris Holmberg, ***Editor***
Alan Fischer, ***Contributing Science Writer/Photographer***
With special thanks to Emily Joseph, Carol Neese, and Elaine Owens

[1] United States of America (2011) *Long-term Sustainability of Space Activities*, Conference Room Paper, 48th Meeting of the Science and Technical Subcommittee, United Nations Committee on the Peaceful Uses of Outer Space.

[2] Head, J.N. and Hans Haubold (2012) Space Weather Societal Impacts Workshop and Seminar at the 55th Meeting of the United Nations Committee on the Peaceful Uses of Outer Space, *Space Weather, 10*, S11007,

Displayed in Room One at the exhibition: On the rim of Arizona's "Meteor Crater," showing boulders ejected during the impact. The painting was made on site during a workshop of the International Association of Astronomical Artists.

Room Two: A typical Paris cafe on Blvd. St. Michel, painted in Paris on the way to a scientific meeting elsewhere in Europe.

Room Three: This painting, which portrays impact-ejected boulders stacked in the low-gravity environment of Phobos, sold during the show.

William K. Hartmann Painting Exhibition and Benefit *by Alan Fischer and Chris Holmberg*

A unique exhibition of paintings by PSI Senior Scientist William "Bill" K. Hartmann titled *From Tucson to Mars – And Beyond* was hosted by the Northern Trust Bank in Tucson from Nov. 9 through Dec. 27, 2012. Three gallery rooms at the bank showed paintings from Arizona/Sonora, scenes of international travel, and astronomical visualizations of other worlds.

As well as being one of the founders of the Planetary Science Institute—which celebrated its 40th anniversary in 2012—he is an internationally known painter and writer. Bill is also the recipient of numerous awards for his research and is the first winner of the Carl Sagan Medal from the American Astronomical Society. The medal recognized his work in communicating planetary exploration to the public. "I think of outdoor painting as a way to connect with nature," Bill said. "In that way, it's part of my scientific work and my humanity — as I paint and learn about Earth, I'm learning about one of many planets."

The 65 displayed paintings ranged from San Xavier and Father Kino's headquarter mission site in Sonora to Paris scenes and visualizations of Mars and other planets. Half the proceeds from painting sales at the exhibit were split between Tucson's non-profit Planetary Science Institute, where Bill continues his research as a Senior Scientist, and a student travel grant fund started by Bill to support student travel to conferences of the Division of Planetary Sciences of the American Astronomical Society (DPS). The show raised $1,471 for PSI and the same for the DPS fund.

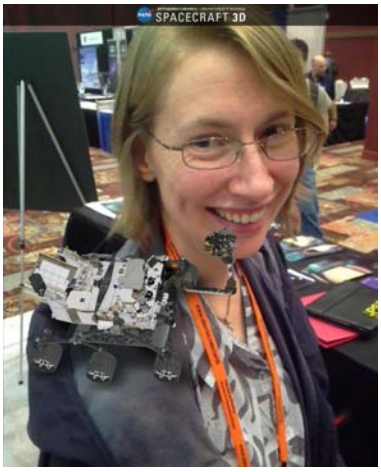
Bill's paintings have appeared as covers for the *Economist*, *Natural History*, U.A. Press books and other media. They have been shown and collected in America, Europe, and Russia. After a 1996 exhibition of astronomical art at Chicago's Adler Planetarium, the *Chicago Sun Times* called Bill Hartmann "the most traditionally artistic of the space painters." Also in 1996, famed science fiction writer Arthur C. Clarke wrote, "I consider him to be the direct successor of the late, great Chesley Bonestell," the father of astronomical painting.

At the opening reception, Bill Hartmann (right) discusses a view of the Moon-family collision with Tucson artist Chris Tanz and her husband, Jean-Paul Bierny.

A Little Bit of Everything

by Elizabeth Jensen, PSI Associate Research Scientist

"So, what do you do?" is a very subjective question that often comes up in conversation. I usually pause and think to myself "what sort of answer are they looking for?" On social networks, I'm a rocket scientist whose idea of fun involves going to electronics stores on Saturday nights; with lawyers, insurance agents, and witnesses, I'm the engineer and physicist they hire to look into a nasty problem given limited information. I hope my colleagues view me as the by-product of an insatiable curiosity, as they never get a short answer when they ask.



Elizabeth Jensen at the American Astronomical Society's Division of Planetary Science annual meeting (AAS/DPS) as the Mars Curiosity rover debuts its 3D projection.

In 1996, I worked with my friend and esteemed colleague, PSI Senior Scientist Faith Vilas, on a project that had piqued her curiosity: Can we look for water-hydrated minerals on the Moon using Galileo spacecraft images? There were permanently dark-shadowed regions on the Moon and lots of comets over its history, so why not? It turned out that the answer was "very probably." Now, after learning about the changing densities of water group ions across the lunar surface, the answer is "I'm almost positive." On a side note, another esteemed colleague PSI Senior Scientist Deborah Domingue-Lorin taught me how to register these images, which has been very useful when performing accident reconstruction investigations.

Between measuring electrical currents from breaking rocks in the lab, to reducing radio frequency measurements of the solar atmosphere using spacecraft across the solar system, graduate school passed much like strolling through Tolkein's mines of Moria with my dissertation advisor, Chris Russell, serving as a kinder, gentler Balrog (i.e., with a sense of humor, much dedication, and plenty of support).

After graduate school, with a second homo sapiens occupying my abdomen, it was time to consider priorities: family first and do less science versus move to Houston and live near grandparents to keep working hard on science. My forbearing spouse only stipulated one rule: not next door!

Since then, I have worked part-time in forensic engineering and pursued my Professional Engineering (PE) license in Fire Protection. Faith and I worked together again, this time on scanning the gravitationally-affected region around Vesta for little "Vestoid" satellites, a negative result but with a new boundary condition. As the project was concluding, I thoughtlessly commented at a MESSENGER spacecraft meeting, "Oh, look, MESSENGER could measure the magnetic field of the solar atmosphere in 2009." Liking the idea, Faith supported the challenge on her MESSENGER grant; I later nicknamed it The Experiment from Hell.

Nine months and four observing proposals later, we were awarded observing time to work on the Green Bank Telescope, WV, the largest steerable radio antenna in the world. However, two weeks before the experiment, MESSENGER went into safe mode and all non-essential operations ceased, making the operators extremely nervous about continuing the experiment. On the trip to Green Bank, I acquired an acute case of food poisoning and ended up in the emergency room; there were issues with acquiring the signal; and then there were issues with processing the data. In the end, we did something that hasn't been done since the 80s: detected magnetic waves in a critical region of the Sun, making it all worthwhile.

After joining PSI in 2010, I met a brilliant scientist at Johnson Space Center, Sue Lederer. She needed a post-doc to work on her grant looking at infrared absorbance's of minerals, specifically before and after being impacted by ceramic projectiles fired from a large gun. So what if it didn't have the hum and whoosh of cryogenically cooled radio equipment? The experiments have fired up shocking results, and we have begun measuring a nonlinear system under controlled conditions, producing data that is much in demand.

When asked what activities as a young adult started me on the path to science, I answer that I recall being in middle school solving a seismology problem and enjoying the way things fit together. It was then I knew I had to do this for the rest of my life!

So, after earning my Bachelor of Science degree with honors at Texas A&M (with a minor in Oceanography), I received my Master of Science in Geosystems at MIT. My Ph.D. is from UCLA in Space Physics. And although it is not a college degree, earning that Professional Engineer license in Fire Protection was just as difficult as acquiring my bachelor's degree.

So, the short answer to what I do is "a little bit of everything," and I love it!

Director's Note

It has been an exciting few months as PSI has added an additional 3,700 sq. ft. of office and conference space at our Tucson headquarters. Much of this had to be constructed within the new facility, requiring us to give much thought to the design. A major consideration was to accommodate more teachers in our WISER training workshops. Towards this end, we designed a conference room with 50% more space than our existing room and installed power in the floors. A wide hallway accommodates our relocated library. The Geosciences Laboratory now has a home filled with more natural light. The entire Conference Center is a very attractive space.

We are already planning our next expansion to double the size of our Conference Center and add a facility to support the Atsa Suborbital Observatory where the flight telescope and instruments will be built and where we will train future operator-astronauts in a simulator of the XCOR Lynx. We look forward to sharing this with the public and students, giving them something of the experience we will be having as we prepare to extend our human activity in space.

Continued on the next page

Glad to be On Board

by Robert M. Nelson, Ph.D., PSI Senior Scientist

Robert Nelson with his original '67 Chevy.

It was my great pleasure to become affiliated with Planetary Science Institute last year, after having served as a scientific research worker at Jet Propulsion Laboratory (JPL) for 34 years. At PSI it is gratifying to find many past JPL colleagues who have walked this path before me. I look forward to learning the PSI way of advancing the field of planetary science.

Planetary science has changed dramatically in the three decades since I finished my graduate studies at the University of Pittsburgh, packed my worldly possessions into a battered 1967 Chevy Bel Air, and headed west to Pasadena to begin a National Research Council post-doc at JPL. Back then, groundbased spectrophotometry was the principal tool for studying the outer solar system. My thesis work, on ultraviolet-visual and near infrared spectroscopy (UV-Vis) of the Galilean satellites, was constrained at the short wavelength end by atmospheric ozone absorption and at the long wavelength end by the limited response of photomultiplier tubes in the infrared. The principal findings from the research were consistent with the suggestion that sulfur, in one or more of its allotropic forms, could explain Io's (a moon of Jupiter) spectrum and that these allotropes could be created on Io as a consequence of volcanic activity.

Concurrent with my arrival at JPL, expanded ultraviolet spectral investigations became possible with the launch of the International Ultraviolet Explorer. IUE, a joint NASA ESA project, broke the ozone barrier — at last we could probe the ultraviolet spectrum. Just as we finished the first IUE investigations of the Galilean Satellites, JPL's Voyager spacecraft passed through the Jovian system and Io's volcanic surface was revealed. Voyager also found SO_2 gas (sulfur dioxide) in Io's atmosphere. In a joint JPL-UCLA lab experiment we measured the spectral reflectance of SO_2 frost. The UV spectral features we saw on Io with IUE were consistent with our laboratory spectrum of SO_2 frost. We established that the SO_2 frost was distributed asymmetrically with longitude on Io's surface — one hemisphere had much more than the other. Needless to say, we were very excited.

One of the great problems with a scientific research career at JPL is that despite the exciting discoveries, management demands its pound of flesh – several pounds in fact. A scientific researcher can't be supported for long on research funds alone. The researcher must lend support to the missions. Fortunately, each mission carries many scientific experiments and each experiment requires a scientist in residence at JPL to meet the instant demands of the project manager. Voyager provided me this additional opportunity — I became the Voyager Photopolarimeter Experiment Representative. While in project-land I became acquainted with two recent physics graduates from Cal State Fullerton, as Voyager continued its path to Saturn, Uranus and Neptune. These two women finished masters degrees, had children, and finished Ph.D.'s at UCLA, all while the Voyager spacecraft traversed interplanetary space.

The next big step for me was to be selected as a member of the Visual and Infrared Mapping Spectrometer (VIMS) for the Cassini Saturn orbiter. I was excited twenty years ago when the formal selection letter arrived in the mail. When the first Cassini Project Science Group meeting occurred, I was pleased to find my two friends from Voyager had also been selected for Cassini. Candy Hansen, who preceded me in moving to PSI as a Senior Scientist, is a member of the UVIS (Ultraviolet Imaging Spectrograph) team and Linda Spilker, still at JPL, now serves as the Cassini Project Scientist. UVIS included another former JPL colleague who is also a Senior Scientist at PSI, Amanda Hendrix.

A responsible scientific career also requires service to the professional community. During my first 18 years at JPL, I also co-hosted a weekly one hour radio show called *The Wizards* on KPFK in Los Angeles. Each week my co-host and I interviewed a scientist about the work they do. Because of this media experience, I was asked to serve as Press Officer of American Astronomical Society's Division for Planetary Sciences (AAS/DPS). These two terms lasted six years. Later, I served as the Chair of the Society, a responsibility also filled by many PSI colleagues including Candy Hansen and PSI Director Mark Sykes.

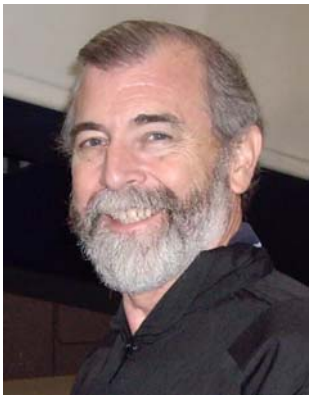
The Cassini investigations continue. Cassini VIMS pioneered the exploration of the surface of Titan (Saturn's largest moon). VIMS infrared images of Titan's surface now suggest both morphologically and spectroscopically that Titan's surface may be active.

All of this work now continues at PSI. The personal friendships made over the years remain. In addition, I still have the 1967 Chevy parked in the driveway.

Note *Continued from page 4*

Needless to say, our plans do not stop there. Pending success in other initiatives, including in meteorite detection, collection, and curation, we will be looking towards further expansion to accommodate laboratory and additional office space.

The main cloud on the horizon is the impact of sequestration on top of the recent cut of 20% by the Administration to the NASA Planetary Science Division. These are major challenges that require pushback by everyone. In the meantime, we are not tempering our ambitions for science, education, and exploration!



Mark V. Sykes
March, 2013

3D Mapping of Erupting Volcano in Hawai'i

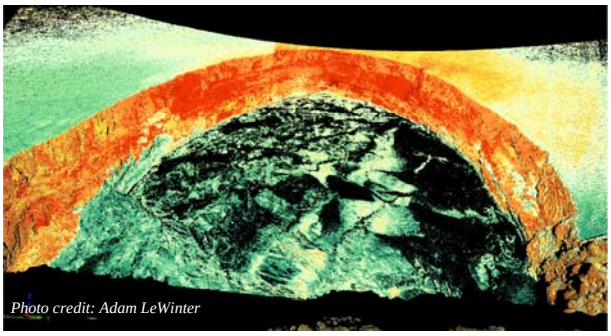
continued from front page

The eruption is occurring in several locations, including within a roughly 160 m-wide cylindrical vent within Halema'uma'u Crater at the volcano's summit, and at Pu'u 'Ō'ō, a cinder cone on the volcano's east rift zone from which a complex lava flow field extends for about 11 km to the Pacific Ocean.

The research team collected video footage and topographic and thermal datasets of the active lava lake at the volcano's summit and active lava flows on the coastal plain. Topographic data of the evolving volcanic terrain were acquired using a tripod-mounted laser scanner called LiDAR (**Li**ght **D**etection **a**nd **R**anging) that obtained data points at the speed of 122,000 pts per second to make high-resolution 3D maps documenting changes in the volcanic activity.

The research team included Steven Anderson, David Finnegan, Adam LeWinter, Matthew Patrick, and Tim Orr.

Steam plumes (above) occur as molten lava pours into the ocean after flowing down the flanks of Kīlauea Volcano in a series of lava tubes. Since these eruptions began in 1983, over 500 acres of volcanic rock have been added to the island of Hawai'i.



At left, 3D LiDAR scan of the erupting crater from overlook; active lava lake surface (green and black), steep crater walls (red and orange), and older flows on floor of Halema'uma'u Crater (yellow and green).

Small lobe of smooth, undulating lava (right), known as pāhoehoe, has emerged from a lava tube on the coastal plain of Kīlauea Volcano, Hawai'i.

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