universe

JPL

August 2019

Featured Stories

(Photos by Ryan Lannom)

Paul Pangburn Is Living History At JPL

By Celeste Hoang

On a sun-drenched Wednesday morning at the tail end of July, Paul Pangburn stands in the middle of four technicians inside JPL's Structural Test Laboratory, the American flag and NASA and JPL logos hanging high on the wall above the group. They're gathered around a large fixture, trying to proof the weight it can carry in order to lift and move the current Mars Science Laboratory engineering model from the Mars Yard to Building 317. It's time for MSL to find a different home so a new generation can be ushered into the sandy space: the Mars 2020 engineering model.

As Pangburn fields questions and provides directions with gusto, he stands out from the group of men surrounding him. Silver-haired and petite with a sheepish smile, Pangburn has a longer resume than most at JPL: He is 84 years young, with 48 years of experience at the Lab under his belt.

It's 9:30 a.m. and Pangburn has a full schedule ahead of him. He'll continue working on proofing MSL, then he'll coordinate assembly and testing of the NISAR deployment fixture. After that, he'll supervise the manufacturing of sample tubes that will travel on Mars 2020 to bring back Martian soil for study. As an engineering development technician, he is regularly found all over Lab, involved in multiple projects at once, constantly working with his hands.

“I usually only go to my desk to put in my timekeeping,” he says with a grin.

Granted, there are many JPL “lifers” who have accumulated decades of work at the Lab before retirement, but Pangburn is a rare breed. Some 20 years past the common retirement age, he still shows no signs of slowing down.

“I’m proud of it,” he says of his JPL career. “That’s about all I can say. I don’t toot my own horn, I just do my job. My father had a really good work ethic and us kids all followed him.” Then, he adds with a laugh, “Or else.”

L.A. Born and Raised

Pangburn was born in Alhambra, California in 1935, in the thick of America’s Great Depression. It was a time when Franklin D. Roosevelt was President, a loaf of bread cost 8 cents, and Amelia Earhart would become the first person to fly solo across the Pacific Ocean.

One of six children, he was raised all over Los Angeles, moving from South Central L.A. to Silver Lake—back when the neighborhood was still mostly dirt roads—and eventually to Hollywood. His father was a photojournalist for a local Hearst Newspaper, the Herald Express, covering some of the biggest Los Angeles stories of the time, including the infamous Black Dahlia murder in 1947.

When World War II broke out, his father wasn’t drafted in 1942 because he had too many young children to care for. His mother took a job at the Hollywood Ranch Market to earn extra money, and Pangburn remembers having his weight and height taken every month to see if the family would qualify for additional food rations.

But even as history unfolded, Pangburn recalls a happy childhood.

Because his father used his car for work, he had no gas restrictions during wartime. One of Pangburn's fondest childhood memories was the entire family taking all-day drives up and down California State Route 1 along the coast. On occasion, they would get caught in a simulated air raid on the way home and would have to pull over and wait it out. Still, the drives were pockets of joy during hard times.

"Those days were simple and easy," Pangburn recalls. "Life has gotten awful complicated now."

But complexity, it turns out, is somewhat of a specialty for Pangburn.

As a child, he was always interested in "mechanical things," and, as he entered high school in the late 1940s, found himself drawn to his uncle's manufacturing business.

After school each day, he would jump on the street car and head downtown, then catch a bus to East Los Angeles, where he'd help his uncle manufacture tools for companies such as General Electric and Pacific Pump.

"That's what I did," he says simply. "I started in high school and I learned the trade."

Boy, Interrupted

Pangburn had his heart set on a manufacturing career, but at the turn of the decade, the world had other plans: It was the 1950s and the effects of the Korean War had arrived on America's doorstep.

"That kind of interrupted my life," he says. "I was of draft age, so nobody would hire me. So I joined the army."

Pangburn fought from 1952 to 1957, but when he came home, he couldn't get back into manufacturing because of a recession. So he joined his father and brother at the newspaper, doing some copywriting, running errands, and watching ticker tapes come off the wire machines for nearly two years.

In 1959, Pangburn went back to school, earning his associate's degree in engineering at Los Angeles City College on the G.I. Bill. Over the next decade, he married, raised five kids, and worked at more than a dozen manufacturing companies throughout the city, mainly making aircraft parts.

“I’d go from company to company,” he says. “I didn’t move because of money; I moved because I wanted to learn more. I would just go as far as I could and then I couldn’t go further, so I moved on.”

But in 1971, he found a place that was a keeper: JPL.

The Problem Solver

A former colleague who was working at JPL at the time suggested Pangburn interview at the machine shop.

“I thought, ‘Yeah, that’ll be something different from what I’ve been doing,’” Pangburn recalls.

He landed the job and started working in a smaller machine shop in the basement of Building 183. Over the next few years, the majority of his work centered on machining parts for the Deep Space Network. It was the early 1970s and Pangburn would fly out to Goldstone on JPL’s private Beechcraft to train technicians on how to grind the plates on the antennas so they could turn.

Back at JPL, Pangburn machined parts for mission after mission over the years, including Viking, Voyager, Cassini, the Mars Exploration Rovers, Mars Science Laboratory, and TESS. He also managed 65 technicians during the build of MSL’s descent stage, and worked on the magnetometers for Cassini, Ulysses, Magellan, Galileo and Voyager.

The work was often punctuated with memorable challenges.

In the middle of Voyager 1 and Voyager 2, one of the machines in the machine shop broke, so Pangburn and another technician worked double shifts for two weeks to rebuild the machine by hand and get back on schedule. On MER, the project worried that Opportunity’s landing would come in too hard, so Pangburn put in a 27-hour workday to reprogram the software. And on Viking, a contractor “goofed” the diameter where bearings were supposed to fit on the gear shafts. Instead of starting over, Pangburn suggested chrome-plating the bearings and grinding them to size to fit—and they did.

“When something goes wrong, that’s usually when I get a call,” he says with a laugh.

And that’s exactly where Pangburn thrives. These are some of his favorite memories at JPL because of “just how complex” the work was, he says. “That’s what I do to this day. I mostly solve problems.”

Forty-Eight Years and Counting

Pangburn retired once already. He left JPL in February 2014 when his daughter was diagnosed with cancer. She died that year at the age of 53 and two of his grandsons, now 19 and 22, have lived with him and his wife since.

In 2016, Pangburn’s former boss said he needed some help and would like him to come back.

“I told him I was up for it. I was trying to get over my daughter,” Pangburn says, adding: “And the people here always keep me busy.”

These days, he’s also taken on the role of mentor to the Lab’s machinists and technicians. He’s eager to help, in part, because help wasn’t always extended his way when he was younger.

“The old guys I’d go to for help would tell me, ‘Figure it out.’ There are a lot of things I wanted to learn that people wouldn’t let me learn,” he says. “What I’ve always vowed is that if a person comes to me and I have the knowledge they’re looking for, I’m not going to keep it from them. I want them to know, too.”

To that end, Pangburn has steadfast advice for early career hires: Never be afraid to ask questions.

“My uncle taught me that the stupid question is the one that didn’t get asked,” Pangburn says. “I’ve believed that all my life.”

In addition to being mentally fit, Pangburn also stays physically fit.

“You’ve got to be active, you can’t sit around,” he says, sharing that he quit smoking years ago, no longer drinks, and takes vitamins every day.

He’s also happily married to his wife of 43 years and spends his free time fishing—he’ll be in Alaska for the nineteenth time as this story publishes—and reading “everything,” from autobiographies to spy novels.

As for the foreseeable future, he’ll continue working and helping others in any way he can.

“I consider myself lucky. I’ve worked with a bunch of wonderful people here,” Pangburn says. “It’s been quite a career. I’m proud of what I’ve done but I’m also humbled by it.”

Andrea Donnellan lands drone [small UAS] after flying a grid pattern over the M6.4 rupture south of highway 178 near Trona, California. The vehicle is a Parrot Anafi with a 21 megapixel camera. About 1,500 images are collected per location. (Photos: Erik Conway)

The Highs and Lows of Mapping Earthquakes

By Taylor Hill

When the first of a series of earthquakes began rattling Southern California the morning of July 4, Andrea Donnellan had her head underwater—literally. The geophysicist was scuba diving off Kauai's coast.

"I surfaced to 81 text messages on my phone," Donnellan said. "Every time I go on vacation, I always hope there's not an earthquake. This time there was."

She took a red-eye flight back to Los Angeles Sunday, July 7, and by Monday morning, Donnellan was drawing up flight plans for the Uninhabited Aerial Vehicle Synthetic Aperture (UAVSAR) team, and charging up battery packs so her fleet of imaging drones would be ready to fly over the fault breaks at the quake's epicenter near Ridgecrest, California.

Her work is one part of a large-scale effort by JPL and multiple agencies to capture and measure motion before, during and after earthquakes. These measurements help response teams identify potentially damaged infrastructure, and could one day help researchers more fully understand past earthquakes and current earthquake fault behavior. Teams across the Lab are using a range of tools to detect tectonic deformation, including data from spaceborne radar coordinated by JPL's Advanced Rapid Imaging and Analysis (ARIA) team, synthetic aperture radar gathered by the UAVSAR team, and more recently, high-resolution imagery from small drones coming out of Donnellan's Near-Surface Airborne Instruments Lab (N-SAIL).

There are a lot of moving parts and people, which requires a high level of coordination and communication.

“There’s a reason I received so many texts moments after the first quake hit,” Donnellan said. “You have to work with everybody. No one person can do all of it. Everyone has their expertise, and that’s what I love about JPL—we’re all talking to each other.”

ARIA: Satellites and Speed

Some of the first post-quake data came from the ARIA (Advanced Rapid Imaging and Analysis) project, a JPL-Caltech collaboration funded in part by NASA’s Disasters Program.

JPLer Susan Owen was celebrating the July 4th holiday on the East Coast when a relative called to alert her of the first Ridgecrest quake. As project scientist for ARIA, Owen had more than a personal interest in the news, and the geophysics community had more than a passing interest in her response.

The ARIA team quickly flipped the switch to start ingesting radar images of the epicenter zone from the international satellites that feed ARIA. After waiting for at least one of the satellites to make a new pass over the area after the earthquakes, the team combined before-and-after radar images into a map of ground displacement.

Released on July 9, the image of the combined impact of successive 6.4 and 7.1 magnitude quakes spread over Twitter faster than a P-wave, thanks in part to the popular explanatory feed of ARIA team member and JPL geophysicist Eric Fielding.

Save for some manual stitching, ARIA’s software did most of the work.

“ARIA’s effort over the years has been to minimize the human response,” said JPL Chief Scientist and ARIA co-founder Mark Simons.

ARIA receives a direct, real-time feed of earthquake data from the U.S. Geological Survey. The project’s software then fetches data from the partner satellites, with a latency of up to 12 hours.

“And then it starts doing the math,” said Owen.

“The people who are going to go map things in the field need to know where to look for fault rupture, and these ARIA products provide the map,” said Simons. In this case, survey teams were right at the epicenter of the first quake and “holding on for dear life” when the next, larger quake hit on July 5.

On July 12, ARIA Disaster Response Product Lead Sang-Ho Yun and the team followed up by producing a proxy damage map from satellite data showing areas with likely damage from the fault slips and ruptures. The map covers a 155-mile-by 186-mile area, giving a broad view of damage hotspots across Southern California.

Fault rupture: Scarp of the M7.1 earthquake rupture south of Highway 178 near Trona with approximately 50 cm of vertical offset.

UAVSAR: Airborne Radar and Soon an Octo-Camera

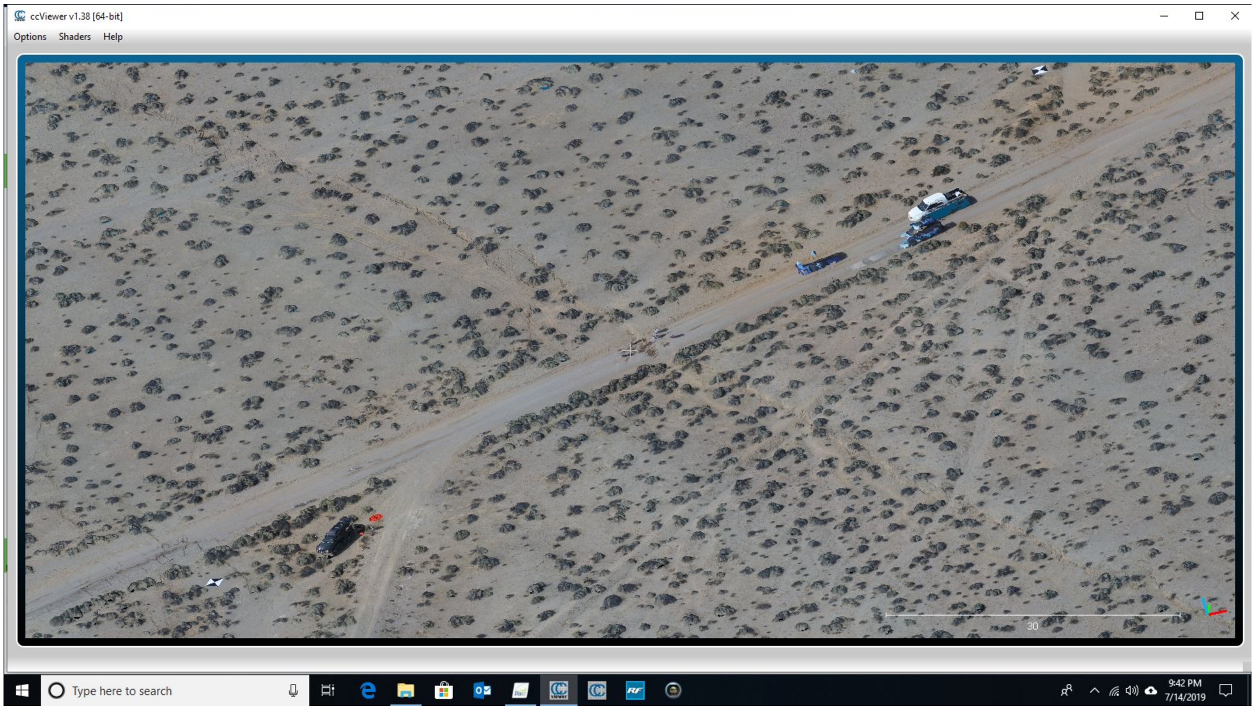
With the ruptures and fault slips mapped out by spaceborne radar, the UAVSAR team can fly their airborne missions over particular areas of interest or damage, and produce higher-resolution data—one to seven meters covered per pixel compared to spaceborne radar's 30- to 100-meter pixel resolution—filling in finer detail on how the fault behaved. In previous quakes, the information helped researchers better understand evolving stress fields after ruptures occur, and determine that fault slips can occur hundreds of miles away from the epicenter, and on entirely different faults.

Unfortunately, the UAVSAR instrument—which rides on the belly of a Gulfstream III jet--is currently flying over Louisiana and Mississippi to aid in data-gathering surrounding Hurricane Barry.

"We made the flight plan for Ridgecrest, but it hasn't been flown yet," Donnellan said. "We're working with headquarters and other scientists to figure out the best approach and to maximize the science that comes out of the instrument when we do get the chance to fly it."

Once they do, the team will be able to try out a prototype flying imager aboard the Gulfstream III as well. The eight-camera system has been outfitted to peer out of one of the airplane's windows and snap pictures capable of creating topographic imagery in resolution of about 50 centimeters per pixel.

"In the case of this fault rupture, which had about three meters of slip in some places, we'll be able to image that really well--the whole rupture," Donnellan said, noting the radar and imaging capabilities would be complementary. "UAVSAR will show you the motion, but it's gathered data at an oblique angle. With our flying prototype imager, you'll get the whole topography. Of course, if there's a cloud in your view, you're not going to get anything, whereas radar sees through the clouds. So, you want all of it."



Part of the reconstructed product on the M7.1 rupture area south of Highway 178 near Trona. The fault scarp can be seen diagonally from lower right side of the image to upper left side. The east side (upper right) has been uplifted about 50 cm and displaced right toward the south about 50 cm. The road has been offset. Lower left side shows the drone landing pad (orange) and a ground control target (white and black). The resolution of the final product is about 2 cm.

Drones: Low-flying, High Resolution Image Gatherers

While awaiting the plane, Donnellan has been sifting through and processing thousands of images she and Greg Lyzenga captured via drone during their field work sessions at the fault ruptures near Ridgecrest. Between July 9 and15, the two spent nearly 40 hours in the field, sending drones up to run grid patterns over the 6.4 magnitude and 7.1 magnitude rupture zones.

It is the first time Donnellan has sent drones from JPL's Near-Surface Airborne Instruments Laboratory (N-SAIL) to snap images of rupture zones following an earthquake. The flights were coordinated with Christine Goulet from the Southern California Earthquake Center, who worked with multiple agencies and groups to make sure teams were not duplicating efforts.

"Other people flew the entire length of the fault, but we were doing really high-resolution, geodetically constrained images," Donnellan said. "We walked around the fault, put down ground control points and surveyed them with a real-time GPS system, so that every pixel is absolute within a centimeter local to each other."

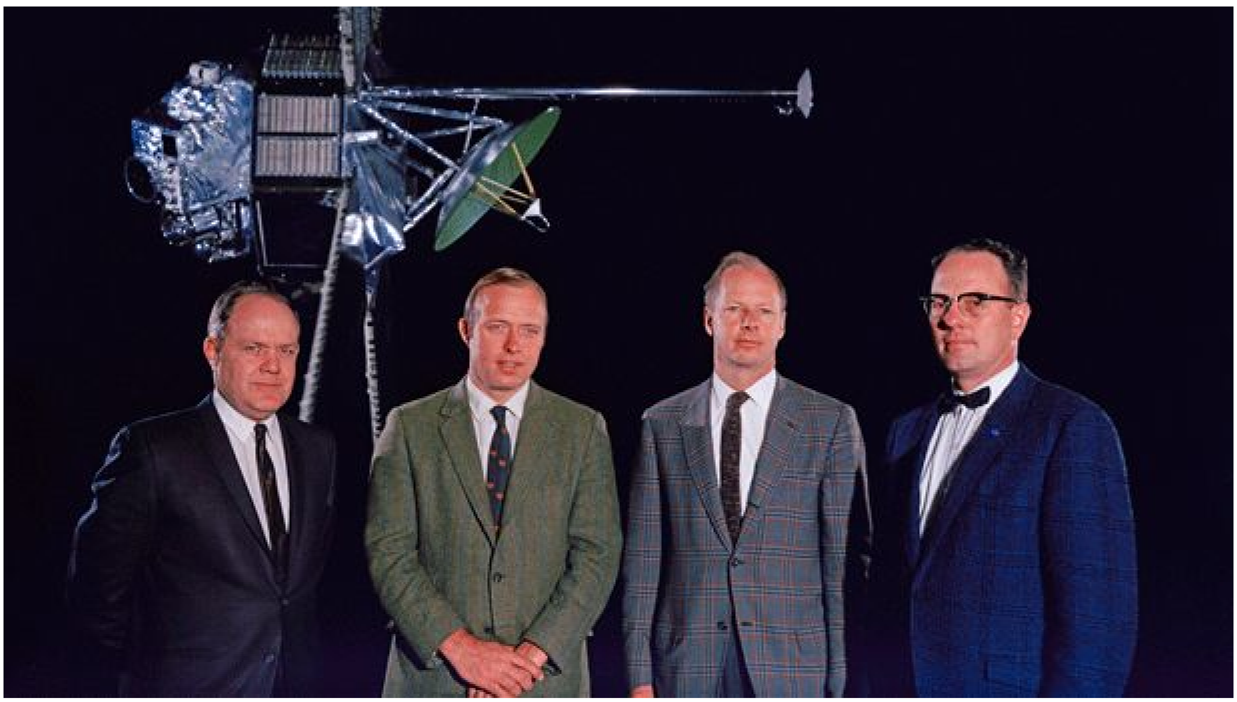
They flew the drones at a 45-meter height, capturing thousands of high-resolution images at around 1.5 centimeters covered per pixel, mapping approximately 450-meter by 450-meter regions over both rupture zones.

Each drone flight took about 20 minutes. Then they would swap out battery packs, download data, and send the drone back up. But the region's summer heat soon started causing issues.

"We brought a cooler bag for the batteries, but we realized that the drones themselves were overheating, so we need to bring the drones their own cooler bag next time," Donnellan said

Despite the heat, the drones completed their task, taking thousands of images that will depict the slightest shifts in surface deformation—not just caused by large earthquakes, but also during "quiet creep" periods along the fault, particularly following earthquakes.

"We've known for some time that faults crept at low levels, but it wasn't until spaceborne and airborne radar began looking at this that we've been able to measure broad creep on faults," Donnellan said. "With the complementary data between the drones, UAVSAR, spaceborne radar, and ground-based GPS measurements, we hope to start making determinations on how much faults are going to creep, and their creep behavior. Are they grinding along silently, or not? How do you have big earthquakes and creep events on the same fault? That's the billion-dollar question, and one that aids in understanding earthquake hazards."



(Left to right) Henry Norris, John Casani, Bud Schurmeier, and John Stallkamp with the MM69 Proof Test Model in the background.

Fiftieth Anniversary of Mariner Mars 1969

By Erik Conway

July 31 marks the 50th anniversary of JPL's second mission to Mars, the twin Mariners VI and VII. Like their predecessor, Mariner IV, they had flyby trajectories and returned swaths of images across the visible disk of Mars. Unlike Mariner IV, they carried spectrometers to begin providing information about Mars' composition. NASA approved the project in December 1965, and JPL appointed Harris "Bud" Schurmeier, who had been the project manager for Rangers 6-9, as the project manager.

The two spacecraft differed substantially from Mariner IV. The availability of the Centaur upper stage starting in 1966 allowed them to be much heavier. The Lab's engineers had also reduced the number of electronic parts by more than one-third through the use of then-new integrated circuits. Most importantly, they had increased the data return capability enormously. Mariner IV had sent its data back at 8 and 1/3 bits per second; Mariners IV and VII had three selectable rates: Mariner IV's 8 1/3 bps, a slightly higher 33

1/3 bps, and 16, 200 bps. The 16.2k rate was used for the encounter phase of the mission to provide a near-real-time data return and display. The recorded data was also re-sent after encounter at the slower rate as a verification.

The instrument suite consisted of an imaging subsystem, ultraviolet and infrared spectrometers, and an infrared radiometer. The imaging subsystem had been proposed by a team led by Robert Leighton of Caltech, and consisted of narrow- and wide-angle television cameras with red, green and blue filters for color reconstruction. The UV spectrometer, proposed by Charles Barth of the University of Colorado, was designed to measure composition of Mars' upper atmosphere. The infrared spectrometer, developed by George Pimentel of UC Berkeley, was also designed for atmospheric composition, though it would provide some surface composition information, too. And the IR radiometer, from Gerry Neugebauer of Caltech, measured surface temperatures.

Caltech's Robert Leighton looking at Mariner 6 far encounter images.

The two spacecraft had somewhat troubled paths to Mars. Mariner VI's Atlas partly collapsed due to depressurization while sitting on the launch pad. While quick action by the ground crew prevented a complete collapse and possibly damage to the spacecraft, that Atlas had to be sent back to Convair's San Diego facility for re-testing. So the Atlas designated for Mariner VII actually launched Mariner VI, and Convair shipped a new Atlas from San Diego to Florida to launch Mariner VII. After launch, both spacecraft suffered from a minor issue also experienced by Mariner IV. Bits of paint or dust would occasionally fool the Canopus tracker that helped maintain orientation, and the operations team would have to intervene to re-establish lock.

The most severe problem occurred just before the two spacecraft reached Mars. Mariner VI was returning its "far encounter" imagery on July 28 when the Johannesburg Deep Space Network station lost contact with Mariner VII, whose own encounter with Mars would be only five days later. After several hours, Mariner VII's operations team was successful in commanding the spacecraft to activate its low-gain antenna, and they regained control of the spacecraft. But it was damaged, off its orientation, and also slightly off course. Months later, a failure analysis would conclude that one or more of the spacecraft's battery cells had exploded. Fortunately, though some of the engineering telemetry channels were damaged and the onboard computer memory was scrambled, all spacecraft systems still functioned, and the operators were able to reprogram the computer. So Mariner VII ended up having a successful flyby despite the damage.

Mariner VI’s closest approach to Mars occurred on July 31, at a distance of 3,431 kilometers (2,132 miles). It returned 49 far encounter images and 26 near-encounter images. Mariner VII’s flyby occurred on August 5, passing 3,430 kilometers (2,130 miles) above the surface. It returned 93 far-encounter and 33 near-encounter images. Infrared spectrometer data indicated the presence of carbon dioxide ice at high altitudes as well as on the surface of the south polar region. The UV spectrometers confirmed prior Earth-based measurements that indicated a mostly CO2 atmosphere with no measurable oxygen or nitrogen. Without oxygen’s presence, there was also no measurable ozone, leaving the surface bathed in ultraviolet radiation.

Harris “Bud” Schurmeier, the Mariner Mars 1969 project manager, with a spacecraft model.

The Mariner Mars 1969 project, ultimately, built four spacecraft. The first, known as the “proof test model,” was completed March 15, 1968, and is on a permanent loan to the Laboratory for Atmosphere and Space Physics in Colorado. Spacecraft 2 and 3, which became Mariner VI and VII, were completed July 25, 1968 and August 20, 1968, respectively. Spacecraft 4, the flight spare, was completed on September 20, 1968. Spacecraft 4 went into storage after the successful flights of Mariner VI and VII, and was later reworked to go to Venus and Mercury as Mariner 10.

Photo by Ryan Lannom.

Retro Chic for Apollo Dress-up Day

When it comes to fashion in 2019, it's probably fair to say that JPL style runs the gamut, but Hawaiian shirts, T-shirts, jeans and similar garb are not an uncommon sight. But back in the era of Apollo 11, there was a whole different style vibe happening here.

To capture the look and feel of that historic time, members of the New Researchers Support Group invited JPLers to dress up like Apollo-era engineers and scientists on July 18, two days before the 50th anniversary of the first Moon landing. Many people heard the call, stepped into their virtual wardrobe time machines, and emerged ready to show up for work in white shirts, narrow ties, business dresses and thick glasses. Some even accessorized with pocket protectors and slide rules.

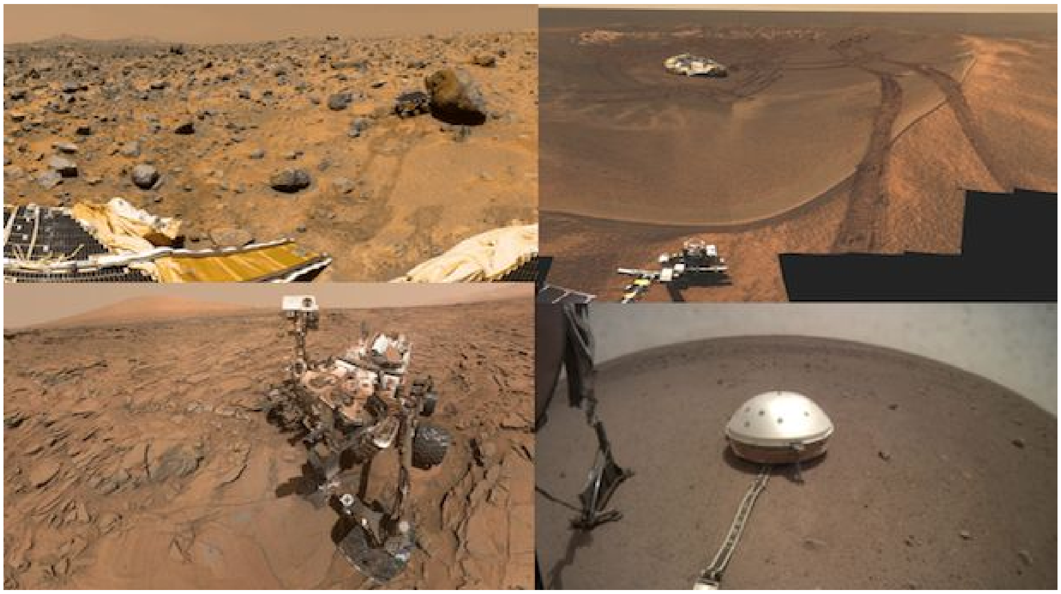
The retro rocketeers gathered in Mission Control for a group photo on Thursday at high noon--shot in black and white, of course.

Events

America in Space

Thursday, Aug. 15
8 p.m.
Hollywood Bowl

In celebration of the 50th anniversary of the Apollo 11 moon landing, hear how Hollywood's composers have been inspired by the achievements of American space travel. A mix of music, film clips, and archival footage will tell the story of our push to explore beyond Earth's atmosphere, from the thrill of the space race to the possibility of missions to Mars. Experts from JPL including Deputy Project Scientist Abigail Fraeman will join the orchestra to underscore the impact of California's scientists and engineers on our achievements in space.

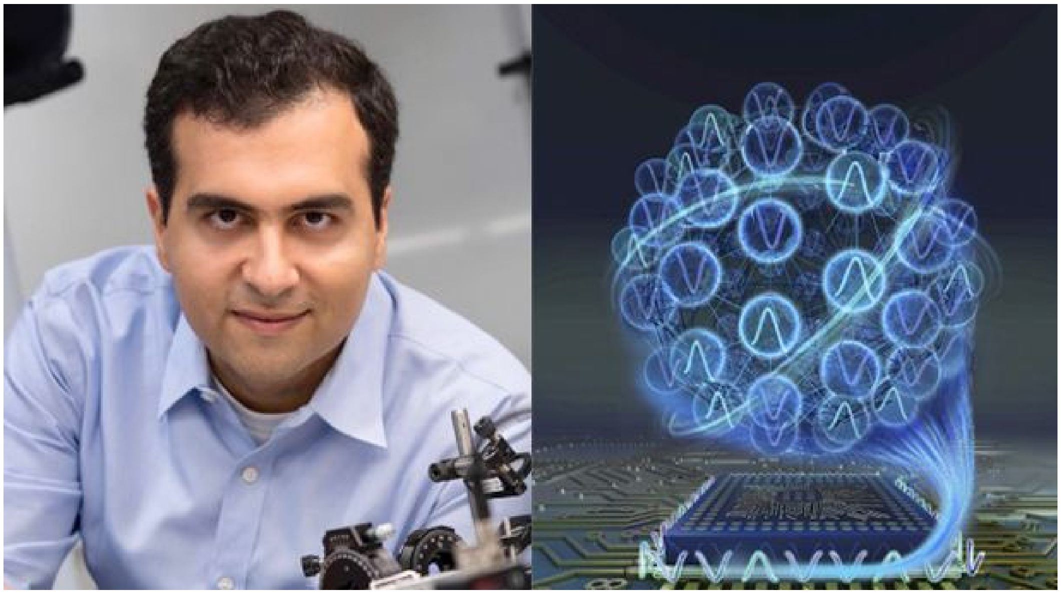


Tales From The Surface Of Mars

Thursday, August 22
Noon to 1 p.m.
von Karman Auditorium

Presentation by Rich Welch

Since the Pathfinder mission landed on the surface of Mars 22 years ago, JPL has had four more successful surface missions and continuous surface operations for the past 15 years. While JPL has advanced the state of the art of our robotic Mars surface explorers, many of the same challenges still exist and all mission have their share of surprises during surface operations. Rich Welch's career path supported most of these missions starting as a Sequence Engineer for the Sojourner rover through most recently Mission Manager for InSight. This mission chronicle talk will provide highlights from these missions and discussion how development and operations of Mars surface missions has changed over the past 20-plus years.



OCSCT JPL Caltech 2019 Seminar Series

OCSCT JPL - Caltech 2019 Seminar Series
Thursday, Aug. 22
1:30 to 2:30 p.m.
180-101

Half-Harmonic Generation: Enabling Photonic Solutions for Molecular Sensing and Non-Classical Computing

Speaker: Alireza Marandi, assistant professor of Electrical Engineering and Applied Physics at Caltech

Half-harmonic generation is a nonlinear optical process that is the inverse of second harmonic generation, in which photons are split into pairs of identical photons. This process can occur in optical parametric oscillators at degeneracy. Its intriguing characteristics such as intrinsic phase and frequency locking as well as the possibility of generating quantum states of light have opened unique opportunities for practical and scalable photonic techniques for molecular sensing and non-classical computing.

Hosted by the Offices of the Chief Scientist and Chief Technologist, this talk will cover the concept of half-harmonic generation and review the results of how this process can be utilized to realize efficient sources of optical frequency combs in the mid-IR using the well-developed near-IR frequency combs. it will show conversion efficiencies of as high as 64%, few-cycle operation at around 4 μm, and how cascaded half-harmonic generation can lead to efficient phase-locked two-octave down-conversion. It will also show how formation of temporal simultons, i.e. bright/dark soliton pairs through this process can lead to enhanced efficiency and pulse shortening. These coherent broadband sources in the molecular fingerprint region of the optical spectrum can enable direct sensing of several molecular species simultaneously.

Moreover, the speaker will discuss how half-harmonic generation has enabled development of a novel photonic computing platform, namely the optical Ising machine. Various combinatorial optimization problems in biology, medicine, wireless communications, artificial intelligence and social network that are not easily tractable on conventional computers can be mapped to the Ising problem, and hence the optical Ising machine offers a scalable path for tackling these problems. We overview a sequence of experiments on development of these half-harmonic-generation-based Ising machines, from their first demonstration, to a recent large-scale realization that can be programmed to arbitrary Ising problems, and one-to-one comparisons with the D-Wave quantum annealer.

The talk will conclude by discussing paths toward chip-scale implementation of half-harmonic generation and quantum photonic engineering.

Alireza Marandi is an assistant professor of Electrical Engineering and Applied Physics at Caltech. He received his PhD from Stanford University in 2013. Before joining Caltech he held positions as a postdoctoral scholar and a research engineer at Stanford, a visiting scientist at the National Institute of Informatics in Japan, and a senior engineer in the Advanced Technology Group of Dolby Laboratories. Marandi is a Senior Member of OSA and IEEE and has received the faculty early career development (CAREER) award of NSF, and the Young Scientist Prize of the International Union of Pure and Applied Physics in 2019.

Back To School Sale At The JPL Store

Stop by the JPL store for all your back to school needs. Get 10% off the entire store through August.

JPL Family News

Retirees

The following JPL employees recently announced their retirements:

Gerald S. Gaughen, 20 years, Section 356B

Barbara J. Lewis, 34 years, Section 2660

Brent Sherwood, 14 years, Section 4100

Passings

Irving M. Aptaker died July 20, 2019 at the age of 93. He was employed at JPL for about 10 years, and his roles included chief engineer, project manager for Voyager 1 and 2 imaging systems, project manager for Galileo NIMS, project manager for Mariner 9 and 10 TV imaging systems (working for Xerox/EOS under contract to JPL). Aptaker received a NASA Exceptional Service Medal in 1994. He is survived by his wife of 67 years, Norma; daughter Susan; son Richard; grandchildren David and Rebecca; daughter-in-law Christine.